POWER

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A DROP OF OIL

I AM A DROP OF OIL.

For years the earth hid me away and I lay dormant, but with every nerve tensed near to the breaking point, ready to show man what a faithful servant I would be to him if he would but release me and call me into action. But cry as I would I could not make him hear, and he went on his way, killing the whale in the sea and the sheep on the land that he might have light.

Even the fat of the swine he used on his crude machines and listened not to my cry until I almost despaired and ceased hoping. But in the year A.D. 1859 man inclined his ear to the earth and heard me. With intense eagerness I waited and listened as the drill came nearer and nearer until one day it broke through the top of my prison and with a roar I gushed forth; I was born, and from that time until the present the earth has been continually drilled in search of me.

See the many forms that I take on. Man pumps me from the earth into large tanks and through long pipe lines to the refinery and into a large still, where I am heated until I become a wild vapor; I am then allowed to pass through a series of cold pipes where I condense to crude naphtha. When no more vapor will pass from me my temperature is again raised, and again I vaporize and change to illuminating oil or kerosene. Then follows the cracking process, which affords more kerosene. My residuum is then further reduced to gas oil, paraffin distillate, tar and pitch. My distillate is then chilled and pressed into crude scale wax and paraffin oil, which afford refined wax and lubricating oils. My crude naphtha is also redistilled into gasoline, benzine, naphtha and other products.

At first man knew not the many things that I could do, and he only distilled off my gasoline and kerosene and burned the rest of me for the heat that I contained; but I kept crying to him, "Use me more, Use me more, I am thy Servant," and gradually he learned to know me and as he learned his machinery became more and more refined. See yonder monster turbine! How smoothly it purrs as it puts out the power to run the whole community and to make a myriad of lights. But listen! It would pull its bearings and drag its fields in ten minutes or less if I did not creep between the moving parts and take away the friction.

Man boasts that he has conquered the air, but it was through me, his slave. Gasoline distilled from me turns those roaring motors that make the power to drive that monster plane at terrific speed. Lubricating oil made from me also keeps those same motors running smooth and cool. Aye, and it was I that made the frightful submarine possible, for I also drive and lubricate its motors.

Wherever industry is, there am I, and man has learned to depend upon me. In every place I lighten his labors. I creep into the locomotive cylinders and into its driving boxes.

I drive mighty ships that travel the seas, and cut down friction in their working parts to the least possible minimum. I plow, pulverize and seed ten acres a day for the farmer as easily as he used to plow two acres.

The electric generator is useless without me, and the engines that drive it whether they be oil, gas or steam. Still I cry out to man: "USE ME MORE, USE ME MORE, FOR I AM THY SERVANT AND WILL SERVE THEE TO THE UTTERMOST."

Contributed by EARL PAGETT

A Diesel-Driven Flour Mill

A Description of a Diesel Installation in a Flour Mill, Covering the Methods of Operation and Adjustments and the Cost of Power per Barrel of Flour

By PAUL KELLER

THE Diesel engine is especially adaptable for flour-mill drive since the power demand is uniformly at full rating. This allows the Diesel to operate at the point of greatest over-all efficiency. More and more the progressive mill owner is coming to recognize this fact, and the Diesel is coming into increasing favor. Among the early installations was that of the Moser Brothers flour mill at Great Bend, Kansas.

The company's original plant, which was steam-driven, was destroyed by cyclone in 1915. Immediately after the wreckage had been cleared away, construction of a new 1,500-barrel mill and a 200,000-bushel elevator was started. The designing engineers estimated that a 400-hp. engine would be ample to carry the mill and the 80-kw. generator used to operate the elevator and for other power requirements.

A 425-hp. Allis-Chalmers twin duplex Diesel having cylinders 18 in. in diameter by 27 in. stroke was installed, along with the usual accessories. It was early discovered that the mill and elevator required far more than 400 h.p., consequently a second engine of the same make and rating was installed in 1917 and the mill output increased to 1,800 bbl. per day.

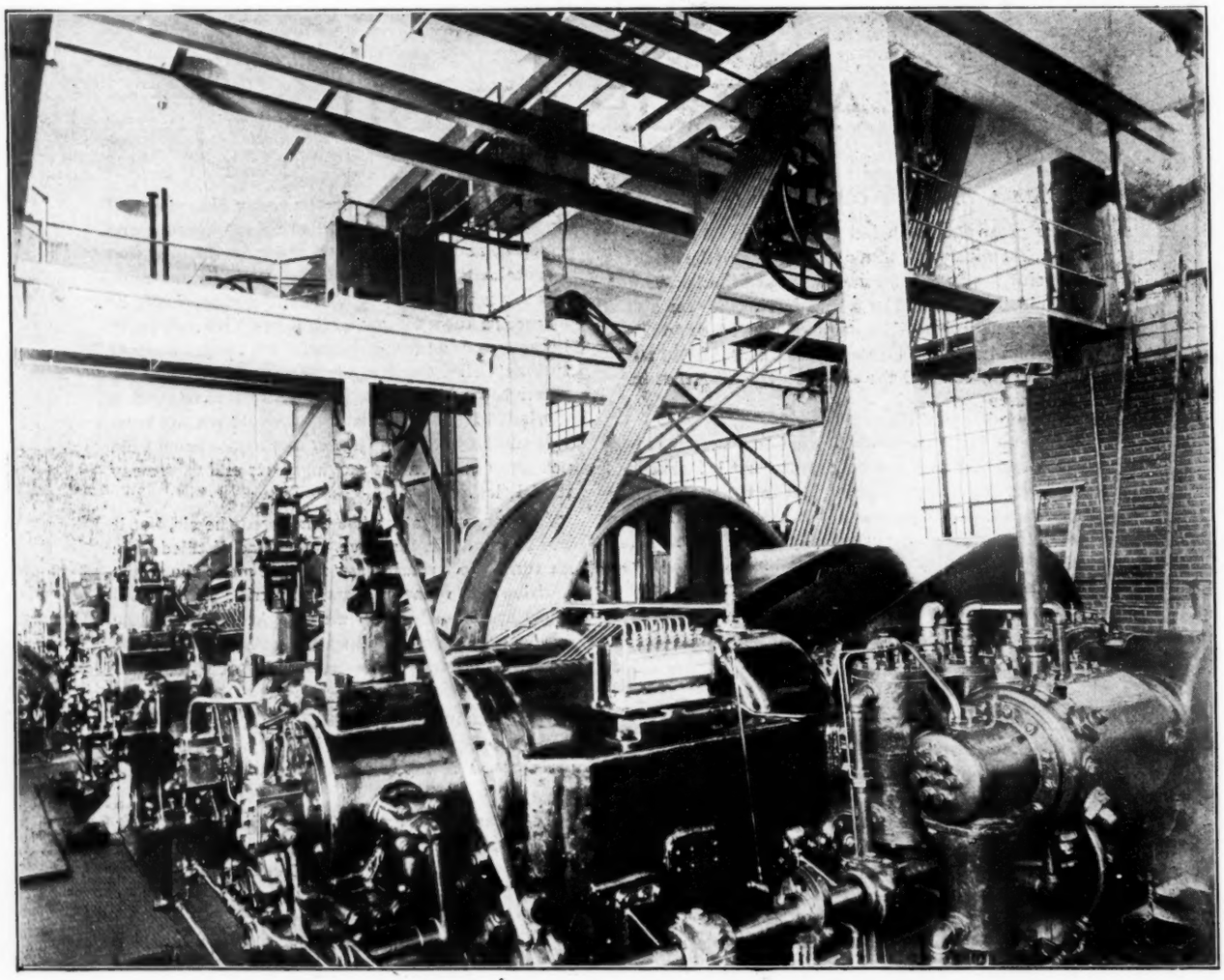


FIG. 1. ENGINE ROOM OF MOSER BROTHERS FLOUR MILL

The two engines appear in Fig. 1. The flour mill is operated by a lineshaft and rope drive. Each engine has an individual clutch for connecting the driven sheave to the main lineshaft. These clutches are so arranged that either engine can be shut down without stopping the mill. The sheave from No. 1 engine, the engine in the background in Fig. 1, is mounted on a quill; the lineshaft passes through this quill to the clutch of No. 2 engine. The generator, which is a 440-

volt three-phase 60-cycle alternator, is driven from the main lineshaft.

As can be seen from Figs. 1 and 3, the engine room is of reinforced concrete with window sashes practically filling the entire sides; it has a floor space 80 x 40 ft. This makes the engine room exceptionally light. The ceiling, which is 30 ft. above the floor, carries the line-

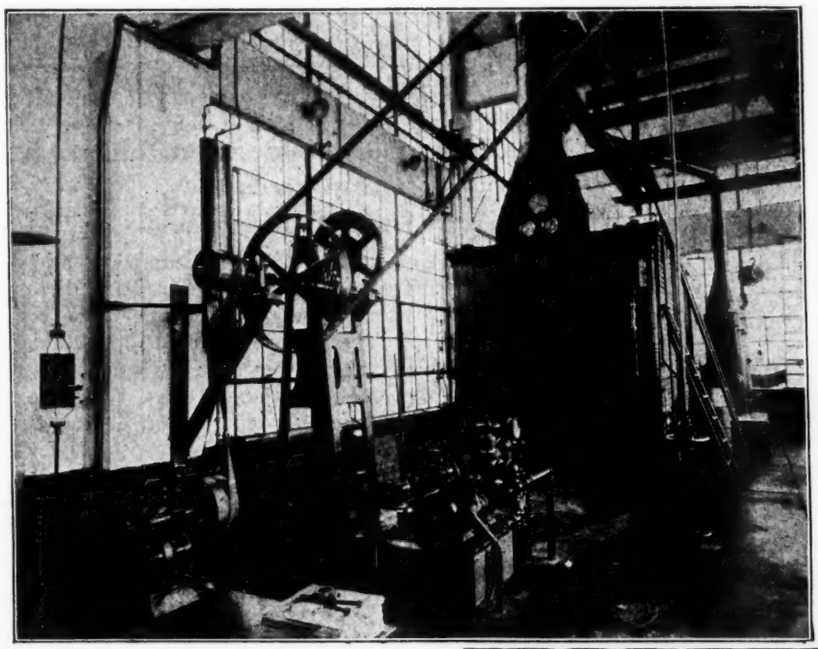


FIG. 2. HEATING BOILER AND DEEP-WELL PUMPS

shaft supports and the trolley beams for the chain blocks.

The engine mufflers, which are long cast-iron chambers without water cooling, are placed in a trench along the front of the engines. The heat thrown off by these mufflers is considerable and made the engine room very uncomfortable. The trench was covered and an exhaust fan was placed at one end. The air is renewed every 30 seconds. These mufflers are connected to a concrete exhaust pit outside the engine room. The volume of the pit is such that no back pressure is placed on the engine and there is no noise.

In the lubrication of the engines some departure has been made from the usual practice. The oil from the engine bearings drains into a cast-iron cellar at the side of the frame. From here it is lifted by a pump on the engine layshaft to a receiving tank some 14 ft. above the engines. The oil is forced from this tank by a $\frac{1}{3}$-hp. electric rotary pump through an Anderson filter press. This press has, for a filtering medium, cloth and blotting paper. Passing through the filter, the oil is then delivered to a four-compartment precipitating tank suspended close to the ceiling. The oil, now practically clean, flows through a Richardson-Phœnix filter and is then ready to flow to the bearings. The filter bags are cleaned once a week with gasoline, while the filter press is opened every two weeks and new blotting papers inserted. As a guard against any stoppage of the oil lines an electrical bell alarm is fitted to the filters. The precipitating tank and filters appear in Figs. 1 and 2 above the engine. Cooling water is secured from two 6-in. deep wells located inside the engine room. The water is raised by two deep-well pumping heads, one of which is belt-driven and operates continuously. The second pump is motor-driven and is used for emergency purposes. These pumps discharge into a concrete cistern from which the water is pumped through the engine water spaces by means of Deming triplex pumps belted directly off the engine crankshaft. After passing through the jackets the cooling water discharges into a sewer. The discharge water is carried somewhat lower than is customary, being around 110 deg. F.; this is done to avoid scale formation. In Fig. 2 are shown the two deep-well pumps and the motor-driven fuel-oil pump. This pump handles the fuel oil from the outside storage tank to the engine tanks at the side of the engine frames. Repairs are frequently a matter of

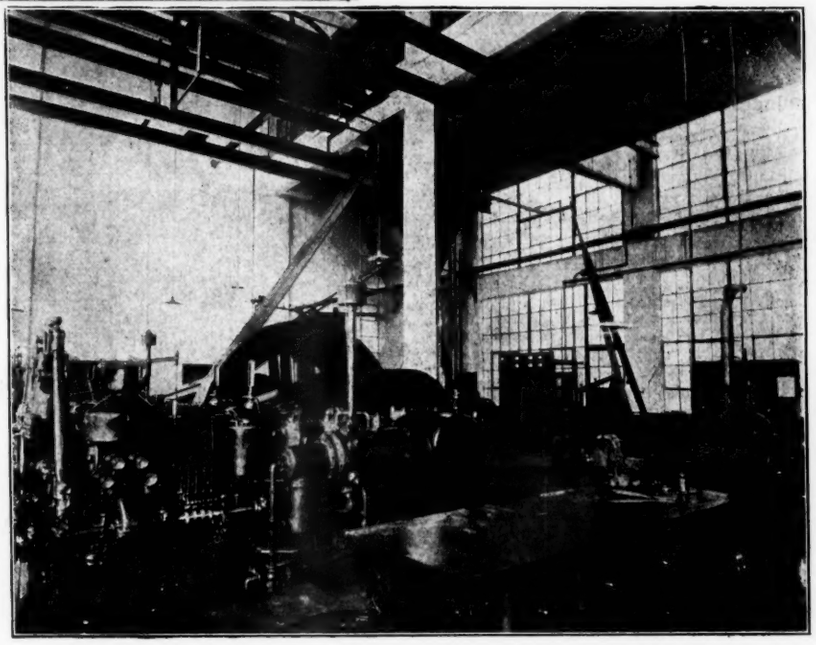


FIG. 3. ENGINE ROOM, SHOWING SWITCHBOARD

criticism against the oil engine. In this plant, at the beginning, there were some shutdowns and cases of piston seizing. These were due to overloading the single engine and to the inexperience of the engineer. Since the installation of the second unit, which allowed the output to approximate three-quarters load on each engine, and a reorganization of the engine-room force, there has been no considerable amount of repairs and only two

engine shutdowns. For a plant operating continuously, this Diesel station compares more than favorably with a steam plant of equal capacity. The repairs of a boiler plant of the same capacity will exceed the repairs required by these Diesels.

The fuel consumption per barrel of flour averages 0.55 gal.; this includes the power used in the grain elevator. The lubricating-oil consumption is somewhat higher than in most Diesel plants. Three gallons of

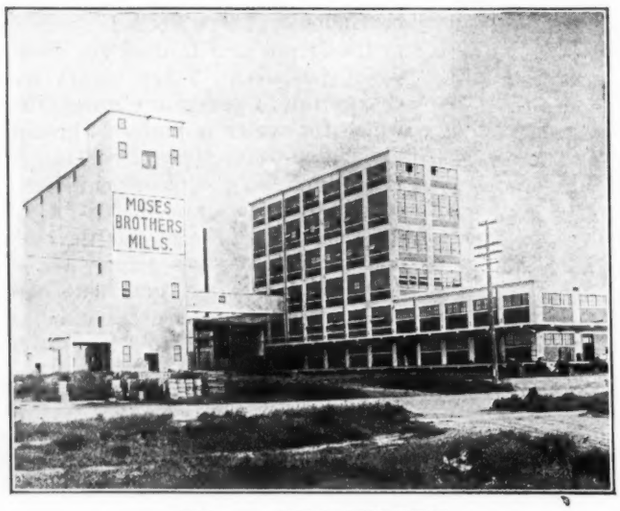


FIG. 4. MILL BUILDING

cylinder oil is used in twenty-four hours or 5,000 hp.-hr. per gallon. Three gallons in 24 hours is also used as makeup in the bearing-lubrication system.

A regular schedule of adjustments is observed, the principal points of which are outlined in Table I.

TABLE I. SCHEDULE OF ADJUSTMENTS

Pull pistons	6 months
Grind admission valves	3 months
Grind exhaust valves	2 months
Grind compression valves:	
1st discharge	3 months
1st stage intake	12 months
2nd stage intake	4 months
2nd stage discharge	4 months
Grind fuel spray valves	2 months
Adjust bearings	4 months
Clean oil tank	4 months
Clean filter	1 week
Clean filter press	2 weeks
Clean Richardson filter	1 week
Clean Anderson filter	2 weeks

The power costs covering a period of one year are shown in Table II.

TABLE II. POWER COSTS FOR ONE YEAR

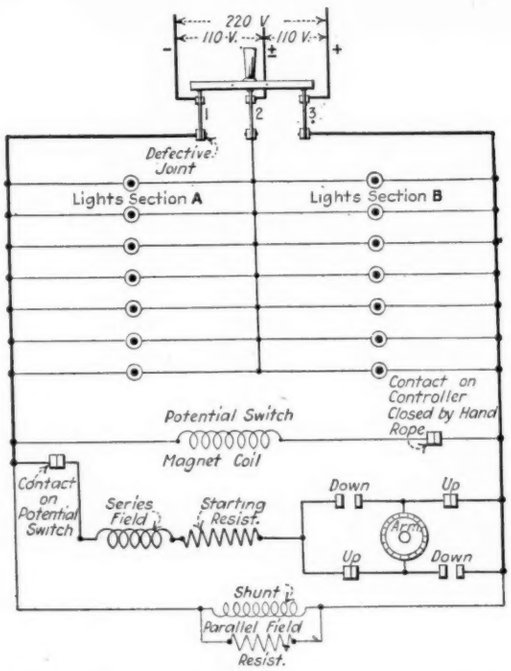
Fuel oil, gal. per bbl. flour	$0.55
Lubricating oil, gal. per bbl. flour	0.0033
Lubricating oil (bearings) gal. per bbl. flour	0.0016
Operating Costs	
Fuel oil per bbl. flour (6.3c. per gal.)	$0.0346
Lubricating oil per bbl. flour (oil at 60c.)	0.0036
Labor per bbl. flour (engineers and helpers)	0.0355
Repairs	0.012
Total operating cost	$0.0857
Overhead Charges	
Interest (7 per cent) per bbl. flour	$0.0324
Depreciation (5 per cent) per bbl. flour	0.0231
Insurance (2 per cent) per bbl. flour	0.0093
Total power costs per bbl. flour	$0.1505

The capacity of the mill is 1,800 bbl. per 24 hours, or 540,000 bbl. per year. However, owing to the freight-car shortage during the period for which the power costs are shown, the mill was not able to operate to its rated capacity. The actual output was but 40 per cent of this amount. The power charges are, as a consequence, considerably higher than would have been the case with a constant output. The decrease in output affects all the charges with the exception of the fuel-oil and lubricating-oil costs. Operating under full load, this total of the power costs including overhead would be close to nine cents per barrel of flour. In calculating the fuel consumption, all kerosene and gasoline used in cleaning the engine and filters are included. The overhead charges are based on the total cost of the engine-room machinery, including the heating boiler.

Elevator Controller Operated Through Lamp Circuit

BY WILLIAM Z. EPERNECK

A peculiar case of elevator trouble occurred on an installation consisting of a hand-rope operated and direct-current geared elevator machine. Power was taken from a three-wire system. The 220 volts across the two outside feeders were used for power, and the lighting system was taken from either outside wire and the center, or neutral, wire to obtain 110 volts. Upon pulling the hand-rope to actuate the controller, the potential or main-line switch would close to operate the motor. However, the latter would not start, but the lights in another section of the building would burn. Upon examination of the main fuses on the service it was found



SCHEMATIC DIAGRAM OF ELEVATOR AND LAMP CIRCUIT

that one outside feeder, where it was sweated into the lug, had a poor connection and was badly burned. Burnt metal is a very poor conductor and is practically equivalent to an open-circuit. Under this condition it will be seen, by referring to the figure, that 110 volts from lines 2 and 3 will send current through the potential switch and the lamps in section *A* to the neutral. The magnet coil was wound of wire of a size that permitted 110 volts to send sufficient current through it to close the

potential switch. This provided a circuit through the armature circuit from line 3 to line 1, the current passing through lamps in section *A*, causing these to light. As it does not require any great amount of current to provide necessary magnetism to hold in the potential switch, this switch remained in, even though bypassed by the low-resistance armature circuit.

The shunt field, being paralleled across the armature circuit and being of comparatively high resistance, would carry such a small portion of the total current that the field strength would be weak, consequently the motor would not develop sufficient torque to start. The remedy, of course, was to furnish a new terminal lug and sweat the feeder in such a manner as to provide a good connection.

A New Year's Letter*

By Frederick L. Ray

Greetings for a Happy and prosperous New Year to all employees of the power-plant department. As your happiness and prosperity is closely linked with that of your employer, there must be a mutual co-operation in order to get the best results, and with this thought in mind we might at this time look about us and give earnest consideration to the condition of the equipment under our care, as to whether it is in the best operating condition and in a condition to give efficient results. The great question in power-plant operation is, Are we getting maximum economy out of the equipment we have? A few questions pertaining to the equipment we have will serve to draw your attention to points in operation which, if carefully considered, will lead to greater safety and economy, and of course to better service.

Boilers

Are the tubes clean inside?
Are the tubes clean outside?
Are the baffle walls tight and built to give minimum loss through the boiler?
Are the soot blowers kept in good order and operated according to direction?
Are the superheaters cleaned inside and outside?
Are the blow-off valves tight, so that we have minimum loss?
Are the walls airtight, so that with maximum draft over the fire we will have the proper CO_2?
Are the dampers in good working order?
Are the try-cocks and glass gages on the water column in good order?
Are the safety valves in proper working order?

Stokers

Are the links in the chain-grate stoker kept in good order, so that there will be a minimum dropping of fuel through the grate?
Are the gears on the stoker drives in good order and in proper mesh?
Are the safety springs on the stokers drive devices kept in good order to prevent breaking of the stokers?
Are the dampers in the stokers kept in good order to prevent excess air under the water box?
Are pressure water boxes set the proper height and distance from the chain to prevent entrance of excess air?

Turbine

Are safety overspeed devices in good order?
Are overspeed devices tested regularly with the turbine in full operation?
Are oil pumps in good order, both the main and auxiliary?

Engine

Are governor belts in safe condition?
Are governors tested for control of the engine at no-load condition?
Are the safety devices on the governor in working order?
Are the engines running without pound in the valve gear or connecting rods?
Are all bolts and nuts on the flywheel tight?
Are the valves tight and properly set?
Are the pistons tight?
Are indicator diagrams taken once a month?

Water Supply

Are all precautions taken against the failure of our water supply?
Are screens kept clear of leaves and rubbish?
Are screens kept clear of mush ice?
Are indicating devices on tanks kept in good order?

Economy

Are boilers operated at the most efficient rating?
Are boilers in condition to give maximum efficiency?
Are boilers giving proper CO_2 records for 24-hour period?
Are boilers kept in service too long between cleaning periods?
Are boilers being operated with too high flue-gas temperature?
Are boiler blowoff valves leaking?
Are boiler baffle walls broken and short-circuiting the gases?
Are all pipe joints tight so that there is no steam to be seen about the plant?
Are all steam pipes covered?
Are all steam traps tight and working properly?
Are we keeping the smoke breaching clean so that we may have maximum draft on all boilers?
Are we treating our feed water properly so that there will be no scale in the boilers?
Are the feed-water heaters kept clean?
Are we keeping the maximum vacuum on turbines and engines?
Are we running engine with the best load factor?
Are we using the minimum amount of cooling water on the condenser?
Are we trying to keep down the cost of supplies by keeping close watch that none of them are wasted?

Safety

Are we taking all precautions to prevent accidents?
Are all ladders safe, tools in good order, guards on machinery where needed, floor clear of rubbish, monkey wrenches in tool box instead of on top of a ladder, and danger signs where needed?
Are fire-fighting apparatus in good order and the extinguisher filled?
Are we prepared for high winds, on smokestack guys, windows, exhaust heads, roofs, etc?
Are we reporting to our safety engineer all dangerous practices and conditions of the plant or equipment?

Your earnest co-operation is solicited to the end that we may all enjoy our work while serving to the best of our ability, so that at the close of another year it may be said of us that we have operated safely, efficiently and in a way that gives excellent service.

*Read before the power-plant employees of the Union Traction Company of Indiana, Anderson, Ind.

The first important hydro-electric power projects in Japan were begun little more than a decade ago. At the end of June, 1919, there were in Japan 720 electrical enterprises representing investments of 825,393,526 yen, as compared with 701 enterprises at the same date one year earlier. At the end of June, 1919, the output of electricity generated by water power was given at 463,437 kw. and that generated by steam power 162,364. During the intervening time many new hydro-electric projects have been launched, and the total capitalization represented now stands at about 1,200,000,000 yen.

Armour System of Power Plant Accounting—II

By O. A. ANDERSON
Motive Power Department, Armour & Company, Chicago

Figuring the cost of producing and distributing refrigeration. An ingenious report system supplemented by numerous charts and table to eliminate calculations. An example traced through to illustrate the methods employed.

AFTER the steam-production quantities and costs have been determined, as outlined in the previous article (*Power*, Jan. 25, 1921), steps are taken to ascertain the cost of production and distribution of the other forms of power-house service. The first of

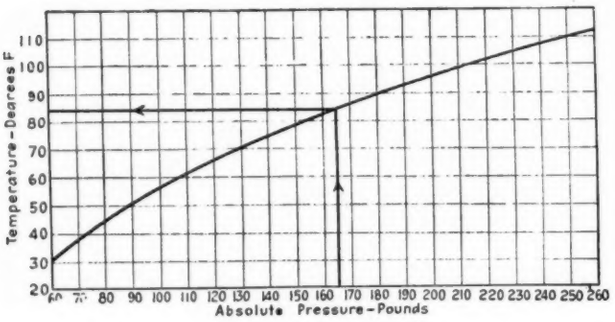


FIG. 1. TEMPERATURE-PRESSURE DIAGRAM FOR AMMONIA

these is refrigeration. The data are entered on the motive-power report sheet designated at Table I. The refrigeration costs have been placed in two divisions—the cost to produce refrigeration as referred to the power house, and the cost of distributing the refrigeration to departments.

Under item No. 1 (a) and (b) are obtained from the machinery records that are maintained on standard forms at all plants and at the general office in Chicago. The manufacturer's rating of the compressor is used. The rated horsepower of the engine is determined for the condition under which it operates during the report period. The figure used is the product of the following three items: namely, a constant "K," the revolutions per minute and the mean effective pressure, the constant being nothing more than the resultant value of the standard steam-engine horsepower formula with speed and mean pressure values removed. This constant is calculated at the time of installation of the machine and recorded on the data forms. Revised calculations are made at such times as cylinders are rebored. From the power-house daily record the revolutions per minute are averaged, and the mean pressure is obtained from curve sheets that have been prepared for varying steam pressures, back pressures, vacuums and cylinder ratios. In all cases one-quarter cutoff is used.

Absolute suction and condenser pressures are recorded to make convenient reference to ammonia tables. Suction- and discharge-temperature readings are recorded every three hours on the daily log sheet and averages referred to the refrigeration statement. These readings prove highly valuable in determining the conditions of suction gas required for most economical compression.

The quality of ammonia suction gas is obtained by referring to curve sheets prepared from the ammonia entropy tables, the procedure being as follows: The degree of superheat is obtained by subtracting the temperature of the ammonia gas corresponding to the condenser pressure from the actual discharge temperature. With the degree of superheat and condenser pressure given, the entropy is obtained from a prepared ammonia entropy chart. The entropy figure thus obtained is referred to the suction pressure and the quality of the gas obtained. This figure is prepared for use in calculating the cubic feet of ammonia gas it is necessary to compress per ton of refrigeration and the adiabatic horsepower required to compress the gas from the suction to the condenser pressure. These values have been calculated and transposed to the curve sheets that have been prepared for different qualities of suction gas, so that the entire operation is largely a matter of referring to charts.

Other data, such as the average inches of vacuum, revolutions and hours of operation, are obtained from the daily log sheets. The total rated horsepower-hours are derived by multiplying the rated horsepower of the engine by the hours of operation.

In calculating the actual quantity of ammonia gas compressed, the volumetric efficiency is determined by the engineering department in Chicago from ammonia indicator diagrams sent in from the the plants, with the temperatures of the suction and the discharge indicated.

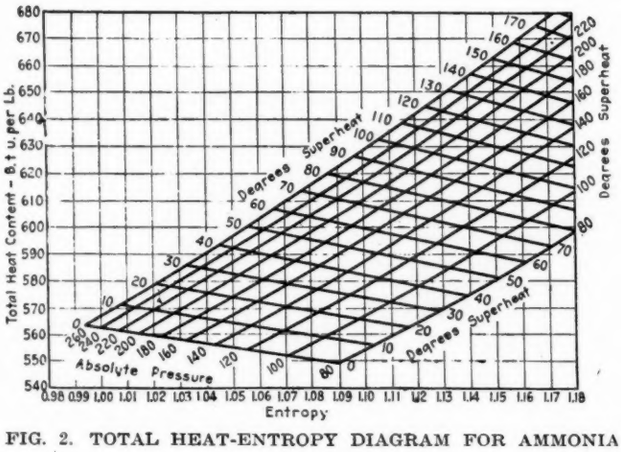


FIG. 2. TOTAL HEAT-ENTROPY DIAGRAM FOR AMMONIA

These values are subsequently given to the outside plants for use on the motive-power statement.

It must be borne in mind that there are three conditions affecting the volumetric efficiency of the compressor; namely, quality of suction gas, condenser pressure and temperature, and loss through the suction valve.

The tons of refrigeration are calculated on the basis of the weight of the dry suction gas corresponding to the suction pressure reported on the log forms, corrected by the efficiency factor. The first loss is that resulting from drop in pressure through the suction valve. This value is determined from gage readings on

the suction line taken simultaneously with indicator diagrams on the suction stroke. Relative to quality, if the gas is superheated, a reduction in weight of ammonia handled will be effected according to the ratio between the specific volume of the dry saturated gas and of the superheated gas. Further, if the gas is entrained with liquid, the reduced volume of effective

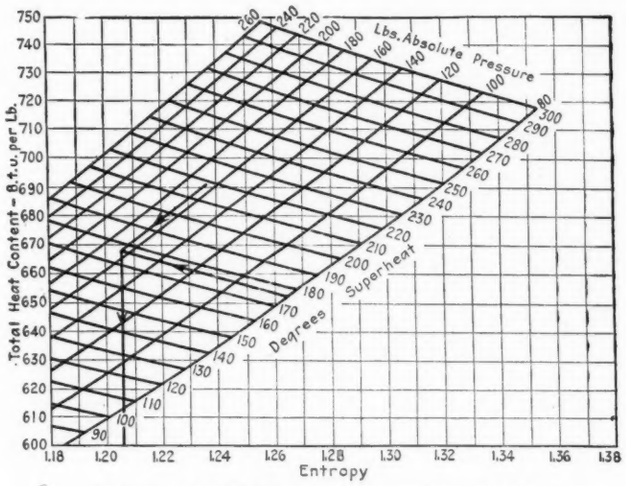


FIG. 3. CONTINUATION OF TOTAL HEAT-ENTROPY DIAGRAM

gas will be determined from the weight of the liquid referred to a gas volume for the suction pressure that is used.

A further loss in the weight of gas which the compressor will pump from the cooling coils will result from the superheat and expansion of the cold inrushing gases upon coming in contact with the hot cylinder walls. If the gas in the cylinder is superheated before compression, this means a loss of weight of ammonia handled,

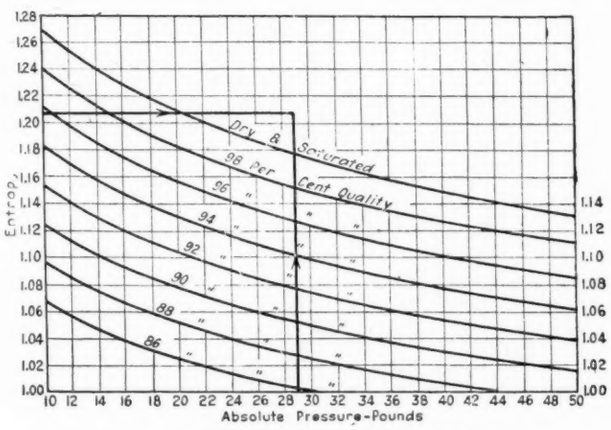


FIG. 4. PRESSURE ENTROPY DIAGRAM

and therefore reduced refrigeration. This loss is, of course, more pronounced in double-acting compressors. It can be estimated only by use of thermodynamic formulas, incorporating the temperatures of the suction and discharge gases. Where measurement of brine can be made, all the losses can be placed in one figure and the refrigeration value compared with the compressor-displacement calculation.

From the machinery record the cubical displacement of the compressor is obtained. The multiplication of this value with the volumetric efficiency will give the cubic feet of ammonia gas, referred to a dry and saturated condition, which is actually compressed in producing refrigeration. The cubic feet of gas per ton of refrigeration is ascertained from the curves in Figs. 5, 6 and 7, in accordance with the quality of the suction gas and the given suction and condenser pressures. These curve sheets have been prepared from the thermodynamic calculation of refrigeration in expanding ammonia liquid from a given condenser pressure to the suction pressure in the lines returning to the compressors. The tons of refrigeration are determined by dividing the number of cubic feet of gas compressed

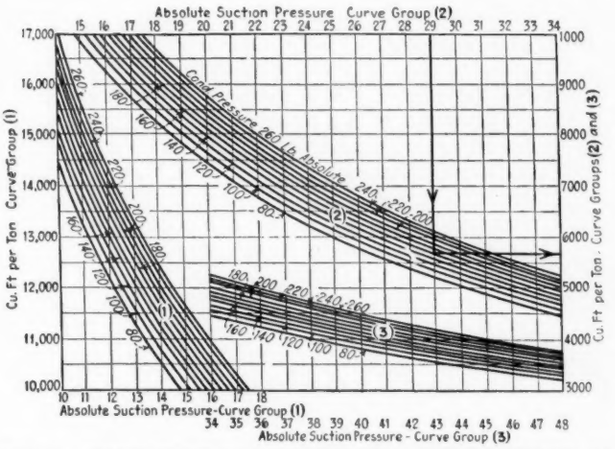

Absolute Suction Pressure Curve Group (2)
Cu. Ft per Ton Curve Group (1)
Cu. Ft per Ton - Curve Groups (2) and (3)
Cond. Pressure 260 Lb. Absolute
Absolute Suction Pressure-Curve Group (1)
Absolute Suction Pressure - Curve Group (3)

FIG. 5. CUBIC FEET OF AMMONIA TO BE COMPRESSED TO PRODUCE A TON OF REFRIGERATION—SUCTION GAS SATURATED AND DRY

by the number of cubic feet that is required per ton of refrigeration.

The next item is the theoretical ammonia horsepower required to compress the gas between the suction and discharge pressures. This has been calculated thermodynamically and subsequently referred to the curves in Figs. 8, 9 and 10. The values from the curves are only preliminary to the calculation of the steam or motor

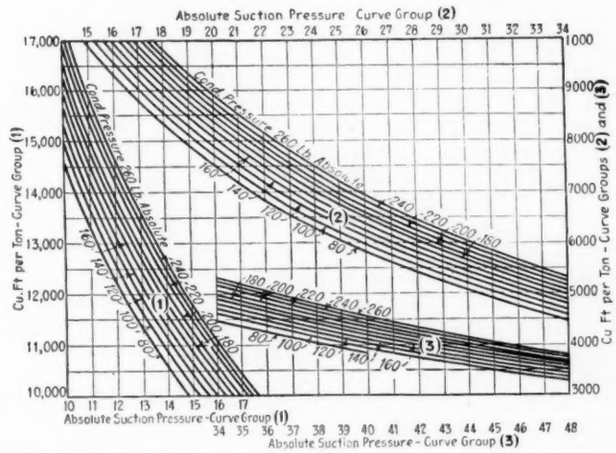

Absolute Suction Pressure Curve Group (2)
Cu. Ft per Ton - Curve Group (1)
Cu. Ft per Ton - Curve Groups (2) and (3)
Cond. Pressure 260 Lb. Absolute
Absolute Suction Pressure-Curve Group (1)
Absolute Suction Pressure - Curve Group (3)

FIG. 6. AMMONIA PER TON OF REFRIGERATION—SUCTION GAS OF 95 PER CENT QUALITY

horsepower required. At the time of taking the ammonia indicator diagrams, steam indicator diagrams are taken also, which are worked up and the ratio of steam horsepower to ammonia horsepower obtained. These figures are subsequently used on the motive-power statement.

As an example of the use of these curves the cubic feet required to be compressed per revolution and the horsepower required per ton of refrigeration will be determined with the following average readings available from the power-house daily record:

Average absolute suction, lb.	29
Average absolute condenser pressure, lb.	165
Average cubical displacement of compressor per revolution	39.3
Volumetric efficiency, per cent	80
Total number revolutions made during period	4,245,000

Referring to Fig. 1 and reading up from the absolute pressure line at 166 lb., it will be noticed that the temperature of the saturated ammonia is 84 deg. Inasmuch as the actual temperature of the discharge is 260 deg. F., the superheat will be 176 deg. In Fig. 3 draw a parallel line between the 170- and the 180-deg. superheat lines. Its intersection with the absolute pressure line corresponding to the 166 lb., projected vertically downward to the entropy line, which is the abscissa, will indicate the value of 1,206. Localizing this value in the ordinates of Fig. 4 and projecting horizontally to an intersection with the vertical absolute suction-pressure value of 29 lb., will indicate that the quality of the suction gas is dry and saturated, and therefore Figs. 5 and 8 will be used respectively in calculating the tons of refrigeration and the horsepower used to compress the gas.

With a suction pressure of 29 lb. abs. and a discharge pressure of 166 lb., refer to Fig. 5, group No. 2, and project the intersection horizontally. The number of cubic feet of gas to be compressed per ton of refrigeration is 5,700. Subsequently referring to Fig. 8 and reading up from a suction pressure of 29 lb. to a condenser pressure of 166 lb., the ammonia horsepower

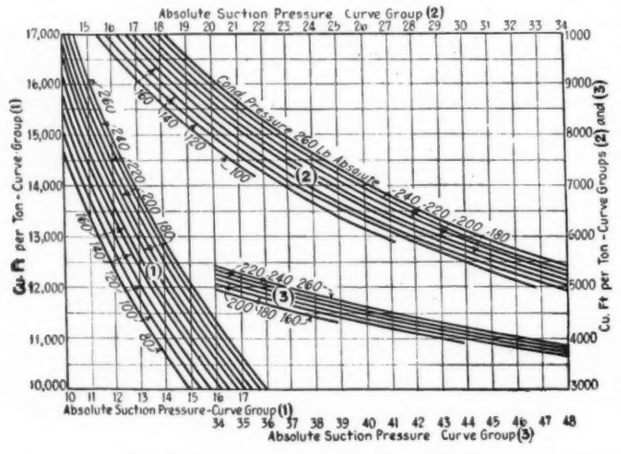

Absolute Suction Pressure Curve Group (2)
Cu. Ft. per Ton - Curve Group (1)
Cu. Ft. per Ton - Curve Groups (2) and (3)
Absolute Suction Pressure-Curve Group (1)
Absolute Suction Pressure Curve Group (3)
Good Pressure 260 Lb Absolute

FIG. 7. AMMONIA PER TON OF REFRIGERATION—SUCTION GAS OF 90 PER CENT QUALITY

per ton of refrigeration will be obtained by reading horizontally across from the intersection to the ordinate value of 1.08.

Multiplying the cubical displacement of the compressor by the volumetric efficiency and the number of revolutions made by the compresor, the total gas actually compressed is 133,462,800 cu.ft. Dividing this value by the cubic feet per ton of refrigeration as calculated will give 23,400 tons of refrigeration, which will be the value represented in item 2(f) of the motive-power report sheet, Table I.

Referring to experience with a particular engine, the ratio between the steam horsepower and the compressor horsepower, as shown by indicator diagrams, is 1.25. This value filled in for item 2 (h) in the report sheet, is multiplied by the ammonia horsepower, 1.08, thus giving the actual steam horsepower as 1.35. Referring to Table II, the steam value for a compound condensing engine is 0.41 boiler horsepower-hour per indicated horsepower, and thus the steam rate will be the product of 1.35 and 0.41, or 0.55. Inasmuch as the refrigeration load is based on 24-hour operation, item 2 (n) will be determined by multiplying the value 0.55 and 24, which will result in a steam value of 13.2 boiler horsepower-hours per ton of refrigeration, assuming that there was

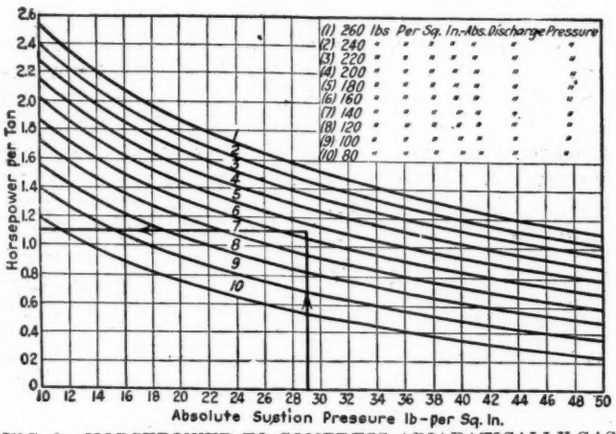


FIG. 8. HORSEPOWER TO COMPRESS ADIABATICALLY GAS REQUIRED TO PRODUCE TON OF REFRIGERATION—SUCTION GAS DRY AND SATURATED

100 per cent load on the engine and a vacuum of 26 in. The steam value per ton of refrigeration may be expressed in pounds rather than boiler horsepower-hours. In this case the pounds of steam per ton of refrigeration would be $13.2 \times 34.5 = 455$.

The product of the ammonia horsepower per ton and the steam horsepower factor will be the indicated steam horsepower required per ton of refrigeration per hour. It will be noticed that item 2 (j) in the report sheet, shows b.hp. per i.hp., or the quantity of steam used per indicated horsepower per hour. This rate is given in terms of boiler horsepower-hours so that the value may be referred conveniently to the number of steam units produced in the boiler room, which is also given in terms of boiler horsepower-hours, or 34.5 lb. of water from and at 212 deg. F. Table II has been prepared to give this value according to the type of engine, number of expansions, type of valves and whether condensing or non-condensing.

Before employing the value of the water rate, two factors of correction are determined and applied to give the true value. These factors correct for the per cent load on the engine and the vacuum carried. After they have been applied and the result entered as item 2 (m), the latter figure is multiplied by the indicated horsepower per ton of refrigeration and by the 24 hours in one ton-day, to give the boiler horsepower-hours per ton for item 2 (o). This value is multiplied by the tons of refrigeration produced to give the total steam used in terms of boiler horsepower-hours.

If the steam goes to a condenser, the full value is charged to the ammonia compressor. If the steam exhausts into a heating or low-pressure drying system, it has been the practice to charge only for one-third of the steam used, due to the high heat value of the steam leaving as exhaust. Should the ammonia compressors be driven by electric motors, the same procedure is

followed, separate items having been provided for this contingency.

In the report sheet the succeeding charges for labor, supplies and repairs are obtained from the cost record books maintained by the master mechanic. A charge is made for lighting and a proportionate charge for space occupied by the refrigerating machinery in the engine room. The reason for this procedure is twofold: In the first place the charge belongs to refrigeration and reduces by that much the cost of generating current and light. Secondly, it also makes more equitable the distribution of power and light charges to the various departments.

For the ammonia charge the actual price paid is entered as item 9 (a). The succeeding item, "Ammonia Expense," is an estimate of ammonia cost based on the unit cost of ammonia per ton of refrigeration, as averaged from the previous year, with corrections made for price and increased or decreased consumption. This item is of value in writing off the ammonia charges, according to the quality of refrigeration produced, as frequently a plant will make heavy charges of ammonia in the spring and middle summer and still produce large quantities of refrigeration in the fall and winter without adding ammonia to the system.

Items 10 and 11 are obtained from another report sheet giving detailed calculations of steam and ammonia condenser costs. These data will be presented in a later article. Item 12 is determined from appraisal values, the equipment included comprising compressors, condensers, connections, engines and the proportionate part of the engine-room building.

Summarizing all items from No. 3 to No. 12 inclusive, there will result the cost of producing refrigeration in the power house, which, divided by the total tons of refrigeration that is produced, will give the unit cost per ton.

After the unit cost of producing refrigeration in the power house has been determined, there is added expense

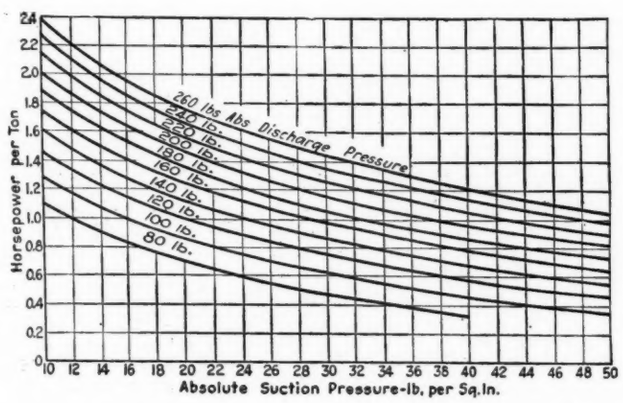


FIG. 9. HORSEPOWER TO COMPRESS GAS PER TON OF REFRIGERATION—SUCTION GAS OF 95 PER CENT QUALITY

in connection with the distribution of the refrigerating medium from the ammonia condensers to the respective refrigerated rooms. This expense is represented in items 14 to 21 inclusive, of Table I. Items 14, 15 and 16 are obtained from the expense records of the master mechanic's office relative to labor employed in maintaining the refrigerating lines and supplies and repairs to same. Items 17 to 20, however, pertain to auxiliary pumping equipment, such as brine pumps and circulating pumps in connection with ice tanks or brine tanks. Item 21 (a) represents the value of the distributing equipment, and it is obvious that overhead values will be written off on the same. The unit cost of distributing refrigeration added to the cost of production gives the total unit cost of production and distribution of

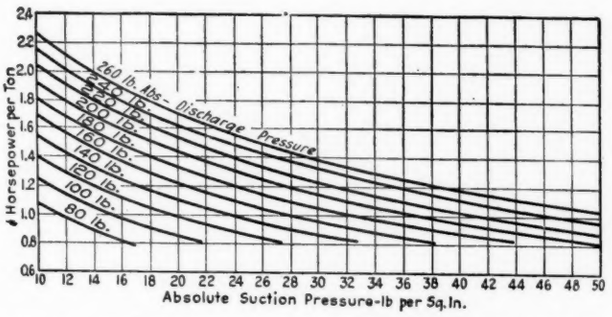


FIG. 10. HORSEPOWER TO COMPRESS GAS PER TON OF REFRIGERATION—SUCTION GAS OF 90 PER CENT QUALITY

refrigeration represented in item 24 (b). Item 25 gives the total cost per ton of refrigeration.

The exact division between the motive-power system and the operating department of the factory are those

TABLE I. MOTIVE-POWER REPORT—REFRIGERATION

1. Data on operation of compressors:				
(a) Number of machine	....	1	....	....
(b) Rated tons refrigeration	....	500	....	....
(c) Rated hp. of engine	....	700	....	....
(d) Type of engine	....	.....	....	....
(e) Avg. absolute suction pres	....	29	....	....
(f) Avg. absolute condenser pres	....	166	....	....
(g) Avg. suction temp	....	.....	....	....
(h) Avg. discharge temp	....	260	....	....
(i) "Quality" of suction gas	....	.....	....	....
(j) Avg. inches vacuum	....	2.6	....	....
(k) Total number revolutions made	....	4,245 000	....	....
(l) Total number hours run	....	1 479	....	....
(m) Avg. speed, r.p.m	....	47.3	....	....
(n) Total rated hp.-hr	....	1,059,876	....	....
2. Calculation of refrigeration produced and power required:				
(a) Volumetric efficiency	....	0.80	....	....
(b) Cu.ft. displaced per rev	....	39.30	....	....
(c) Cu.ft. compressed per rev	....	31.44	....	....
(d) Total cu.ft. gas compressed	....	133 462,800	....	....
(e) Cu.ft. per ton refrigeration	....	5 700	....	....
(f) Tons refrigeration produced	....	23 400	....	....
(g) Ammonia hp. per ton refg	....	1 08	....	....
(h) Factor to obtain actual steam, hp	....	1.25	....	....
(i) Steam i.hp., per ton refg	....	1.35	....	....
(j) Basis b.hp. per i.hp	....	0.41	....	....
(k) Factor to correct for avg. load	....	1.00	....	....
(l) Factor to correct for avg. vacuum	....	1.00	....	....
(m) Corrected b.hp. per i.hp	....	0.41	....	....
(n) B.hp.-hr. per ton refg	....	13.2	....	....
(o) Total b. hp.-hr	....	308 880	....	....
(p) Exhaust steam to	....	Condenser	....	....
(q) B.hp.-hr. consumed (1/3 total, if exhaust is used)	....	308 880	....	....
(r) Kw.hr. per ton refg	....	.....	....	....
(s) Total kw.-hr	....	.....	....	....
(t) Average per cent load on engine	....	.....	....	....

Cost of Production of Refrigeration

3. Cost steam to drive compressors	$———	——
4. Cost electric power to drive compressors	$———	——
5. Cost of labor to operate compressors and condensers:		
(a) Portion of engineers' wages———%	$———	——
(b) Oilers	$———	——
(c) Janitor service———%	$———	——
(d) Cleaning ammonia condensers	$———	——
(e) Operating ammonia condensers	$———	——
(f)	$———	——
(g) Total labor	$———	——
6. Cost of supplies:		
(a) Lubricants, ——gal. of ———@ $———per gal.	$———	——
——gal. of ———@ $———per gal.	$———	——
——gal. of ———@ $———per gal.	$———	——
——gal. of ———@ $———per gal.	$———	——
(b) Waste	$———	——
(c) Steam packing	$———	——
(d) Ammonia packing	$———	——
(e)	$———	——
(f)	$———	——
(g) Total cost supplies	$———	——
7. Cost of repairs:		
(a) General overhauling of compressors	$———	——
(b) Minor repairs to compressors	$———	——

TABLE I (CONTINUED). MOTIVE-POWER REPORT—REFRIGERATION

	(c) Oiling system	$———	———
	(d) Exhaust line to exhaust header	$———	———
	(e) Steam lines to header	$———	———
	(f) Ammonia discharge lines in engine room	$———	———
	(g) Ammonia suction lines in engine room	$———	———
	(h) Liquid-ammonia pump	$———	———
	(i) Engine-room tools	$———	———
	(j) Ammonia condensers	$———	———
	(k) Liquid receivers	$———	———
	(l)	$———	———
	(m)	$———	———
	(n) Total cost repairs	$———	———
8.	Refrigeration portion of engine room lighting:		
	(a) No. kw.-hr	$———	———
	(b) Charge	$———	———
9.	(a) Ammonia put into system	$———	———
	———Lb. @ $———per lb	$———	———
	(b) Ammonia "expense"	$———	———
	———tons rfg. @ $———per ton	$———	———
10.	Cost of water and pumping for ammonia condensing	$———	———
11.	Ice machine portion of total steam condensing cost	$———	———
12.	(a) Total value of compressors, connections and condensers,		
	(b) Annual rental charge, 6%	$———	———
	(c) Annual depreciation charge, 3%	$———	———
	(d) Rental charge for period	$———	———
	(e) Depreciation charge for period	$———	———
	(f) Insurance	$———	———
	(g) Taxes	$———	———
13.	(a) Total cost of production of refrigeration	$———	———
	(b) Cost of production of refrigeration per ton	$———	———
	Distribution of Refrigeration		
14.	Cost of labor:		
	(a) Portion of engineers' wages———%	$———	———
	(b) Temperature men	$———	———
	(c) Expansion men	$———	———
	(d) Knocking ice off suction lines	$———	———
	(e) Pickle tenders	$———	———
	(f) Removing ice from and cleaning out expansion piping	$———	———
	(g) Cleaning out spray nozzles	$———	———
	(h) Testing	$———	———
	(i) Repairs	$———	———
	(j)	$———	———
	(k)	$———	———
	(l) Total cost labor	$———	———
15.	Cost of Supplies:		
	(a)	$———	———
	(b)	$———	———
16.	Cost of repairs:		
	(a) Circulation fans	$———	———
	(b) Brine tanks	$———	———
	(c) Piping in brine tanks	$———	———
	(d) Main suction and liquid lines	$———	———
	(e) Suction accumulators	$———	———
	(f)	$———	———
	(g)	$———	———
	(h)	$———	———
	(i) Total cost repairs	$———	———
17.	Brine pumping	$———	———
	(a) Total M. gallons pumped	$———	———
	(b) Total cost steam for pumping	$———	———
	(c) Total cost electric power for pumping	$———	———
	(d) Total cost labor, supplies, repairs	$———	———
	(e) Rent and depreciation charge	$———	———
	(f)	$———	———
	(g) Total cost brine pumping	$———	———
18.	Other pumps used in distribution of refrigeration	$———	———
	(a) No. pump	$———	———
	(b) Pump used for	$———	———
	(c) M gallons pumped	$———	———
	(d) Total cost steam	$———	———
	(e) Total cost electric power	$———	———
	(f) Total cost labor, supplies, repairs	$———	———
	(g) Rent and depreciation charge	$———	———
	(h)	$———	———
	(i)	$———	———
	(j) Total cost	$———	———
19.	Power to drive circulation fans: ———Kw.-hr. @ $———per kw.-hr.		
20.	Salt for strengthening brine: ———tons @ $———per ton		
21.	(a) Total cost of equipment for distribution	$———	———
	(b) Annual rental charge, 6%	$———	———
	(c) Annual depreciation charge, 3%	$———	———
	(d) Rental charge for period	$———	———
	(e) Depreciation charge for period	$———	———
	(f) Insurance	$———	———
	(g) Taxes	$———	———
22.			
23.			
24.	(a) Total of charges against distribution of refgn.	$———	———
	(b) Total of charges for production and distribution	$———	———
25.	Total cost per ton refrigeration produced	$———	———

TABLE II. BOILER HORSEPOWER PER INDICATED HORSEPOWER

In determining the boiler horsepower per indicated horsepower the following values are used for a load of 100 per cent of the rating of the engine and, in case of condensing units, for a vacuum of 26 in.

Type of Engine	Boiler, Hp
Corliss compound condensing	0.41
Meyer valve compound condensing	0.48
Plain slide or piston valve, comp. cond	0.60
Four-valve Corliss, comp. cond	0.55
Compound slide valve, non-cond	0.98
Compound Corliss, non-cond	0.67
Simple slide valve, non-cond	1.30
Simple Meyer or adjustable valve, non-cond	1.00
Simple Corliss, non-cond	0.80
Simple poppet, non-cond	0.76

points where the ammonia or brine is taken from a main discharge header and discharged from the factory to a suction return. Thus only the distributing mains and returns function as a part of the motive-power distribution system. The piping in the refrigerating rooms is considered a part of the factory machinery pertaining to the particular department in question.

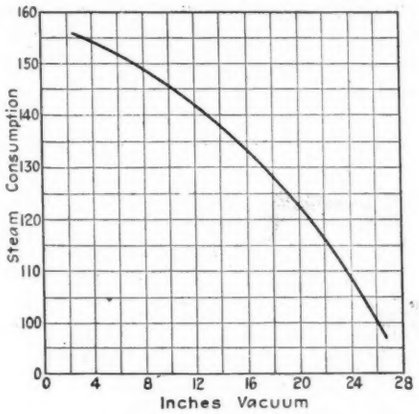


FIG. 11. VARIATION IN STEAM CONSUMPTION WITH VACUUM, STEAM RATE AT 26 IN., EQUALING 100 PER CENT

Boiler-Accident Prevention

In describing a fatal boiler accident, due primarily to low water, the *Travelers Standard* gives some cautionary advice which, if not new, is always timely, and in such succinct and absorbable form that it should be in the hands of every man having to do with boiler operation. It is reproduced verbatim here.

To avoid accidents due to low water in boilers we recommend to all boiler attendants that the following suggestions be kept in mind constantly:

Before starting up in the morning, make sure that the gage glass shows the water to be at the right height. Blow down the water column next, and see that the water promptly returns to its proper level when the blow cock on the column is closed again. Try the gage cocks also, and see that the water level as indicated by them agrees with that shown in the glass.

If the water is low, do not introduce feed water, and if the feed pump (or injector) is running, stop it immediately. If the boiler is one of a battery, shut off the feed pipe running to it, and close the stop valve in the steam pipe leading from the affected boiler to the steam main. As soon as these things have been done, cover the fire with a thick layer of ashes. If ashes are not handy, or if there is but a small quantity of them available, shovel in fresh coal, taking care to cover the fire at every point, until the boiler is effectively screened from the hot fuel on the grates. It is far better to bury the fire in this way than to haul it out of the furnace, because a great deal of heat would be given off to the boiler before the hauling could be completed.

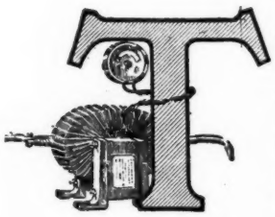
Remember that the boiler has shown its ability to withstand the stress under which it was operating when the water was found to be low, and proceed on the theory that the thing to do is to reduce this stress *gradually* and without any sudden change of any kind whatever.

A Diesel engineer should acquaint himself with the indicator and its uses. Cards should be taken each week so that any faulty valve setting can be detected and corrected.

Instrument Current Transformers

Application of Current Transformers—Effects of Loading and Means of Compensating —Use of Calibration Curves Explained—Table Given Showing Volt-Amperes Required by Various Instruments—How to Demagnetize a Magnetized Current Transformer

By J. B. GIBBS
Transformer Engineer, Westinghouse Electric and Manufacturing Company



THE problem of measuring currents at high voltage or large magnitude would be a difficult one without the current transformer. It would be necessary to bring the high-voltage leads from the main power circuits to the instruments. Not only would this be dangerous to instruments and to attendants, but it would also call for special instruments which could be built only at greatly increased cost and which, for the higher ranges of current and voltage in use today, probably could not be built at all. Instead of this, standard instruments are used on all circuits, and the current transformer satisfactorily reproduces, on a smaller scale and in a low-voltage circuit, the quantities it is desired to measure. For the sake of clearness and to avoid the constant repetition of "the ratio of turns," it is assumed in what follows that the transformers under discussion have a one to one ratio.

All Transformers Are Governed by the Same Laws

The current transformer is governed by the same laws that govern all transformers. When a voltage is applied across the primary terminals, a current will flow in the primary winding. If no current is flowing in the secondary winding, the entire primary current is "exciting current," which magnetizes the iron core of the transformer. The magnetic flux thus set up induces a counter-electromotive force in the primary coil just equal and opposite to the applied primary volts. It also induces the same voltage in the secondary coil. If the secondary circuit is now closed through a resistance, a current will flow, and this current must be balanced by an equal and opposite current in the primary. The primary current now consists of two parts—the "working current" required to balance the secondary current, and the exciting current required to set up in the core a flux sufficient to generate in the secondary coil a voltage that will circulate the secondary current.

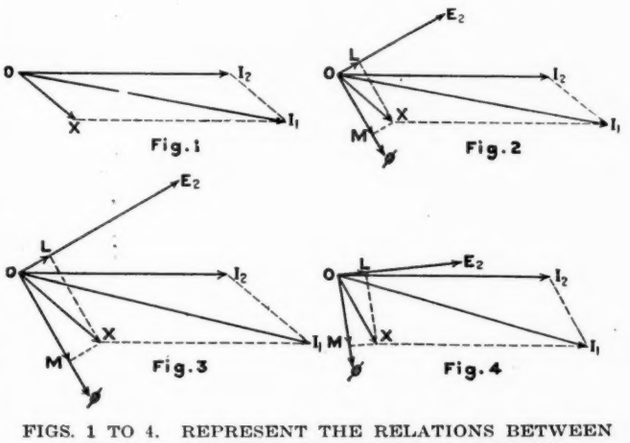
Fig. 1 shows the relation of these currents. I_2 represents the reversed secondary current (or the current in the primary winding which balances the secondary current), X is the exciting current in the primary winding, and I_1, their vector sum, is the total primary current.

In power and voltage transformers it is desirable to have the secondary voltage constant, but in current transformers the requirement is different. The current transformer is usually connected to a fixed load of instruments or relays; that is, the impedance in its secondary circuit is fixed. The primary is connected in series with the circuit whose current is to be measured. An increase in the primary current causes an increase in the magnetic flux in the core. This causes an increase in the secondary voltage, which causes an increase in the current through the secondary load; and this goes on until the secondary ampere-turns again balance all the primary ampere-turns except those due to the increased exciting current.

The secondary current is generally different from the primary current, both in magnitude and in phase position. It is possible to correct the ratio for one particular condition of instrument load by "compensation." This means that the ratio of turns is changed slightly, so that the secondary current is increased enough to compensate for the primary current which is used as exciting current.

How the Instrument Load Affects Ratio and Phase Angle of Transformer

Fig. 2 is similar to Fig. 1, but is more complete so as to show how the instrument load affects both the ratio and the phase angle of the current transformer. E_2 is the secondary voltage induced by the flux ϕ, and I_2 is the reversed secondary current which the voltage E_2 will circulate through the impedance of the meter load. The exciting current in the primary which sets up the flux, ϕ, is X, which is made up of two components, L, which supplies the iron loss, and M, which is the magnetizing current. Thus we have a sort of "house that Jack built." I_2 is the current in the meter circuit, E_2 is the voltage which causes the current I_2, ϕ is the flux which induces the voltage E_2 in the secondary coil, X is the exciting current which sets up the flux, and I_1 is the total current needed in the primary to supply the exciting current X and the secondary current I_2.



FIGS. 1 TO 4. REPRESENT THE RELATIONS BETWEEN VOLTAGE CURRENT AND FLUX IN A CURRENT TRANSFORMER

Now, suppose that more instruments having the same power factor were connected in series with the secondary load. It would take a larger value of E_2 to force the current I_2 through the increased impedance of the meter load. This in turn would demand a larger flux and consequently a larger exciting current, and this would mean that for the same value of I_2 a larger value of I_1 would be needed. This new state of affairs is shown in Fig. 3, and it will be seen that I_1 is larger than in Fig. 2 and lags farther behind I_2; that is, both ratio and phase angle are changed by a change in the meter load. If the power factor of the meter load had been changed without changing its magnitude, we would have had the condition shown in Fig. 4. It will be seen that I_2 and I_1 are more nearly the same size than in Fig. 3, but that there is a larger angle between them. These diagrams give a good idea of the way in which various factors affect the operation of current transformers. In order to show the effect, however, it is necessary to exaggerate the distortion very much. Both ratio error and phase angle are in reality very small.

Ratio and Phase Angle Depend on Amount of Primary Current Flowing

If the flux were always proportional to the magnetizing ampere-turns which produce it, the ratio of I_2 to I_1 and the angle between them would be constant for each value of the instrument load, but this is not the case. Fig. 5 shows the shape of a typical magnetization curve, and it is evident that for double the flux we must have more than double the ampere-turns. The result is that for a given instrument load both the ratio and the phase angle depend on the amount of primary current flowing, and this gives curves of the general form shown in Fig. 6. Compensation, which was referred to in the foregoing, consists in making the secondary winding with several turns less than would be indicated by the transformer ratio, thus

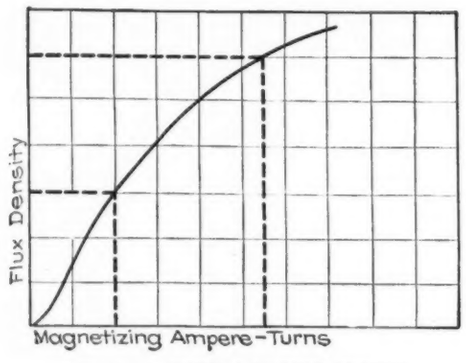


FIG. 5. MAGNETIZATION CURVE

increasing the secondary current to compensate for the exciting current. Obviously, compensation cannot change the shape of the ratio curve. It can merely move the ratio curve downward so as to make it cross the 100 per cent line at the desired value of primary current.

Ratio and phase-angle curves are shown in Fig. 7 for a typical current transformer of good design. The "per cent ratio" is the percentage by which the ammeter reading must be multiplied to correct for the transformer error. Calibration curves similar to these can usually be obtained from the manufacturer by purchasers of the transformers. A typical curve applying, within a certain specified percentage, to any transformer can usually be obtained free of charge. For ordinary corrections this is all that is needed. If measurements are to be made which require the most extreme accuracy, it is necessary to have calibration curves for the individual transformer in use, and it is customary to make a charge for such curves. Such accuracy is seldom required, however, outside of laboratory measurements.

An instrument circuit of 25 volt-amperes is connected to the transformer represented by Fig. 7. If the am-

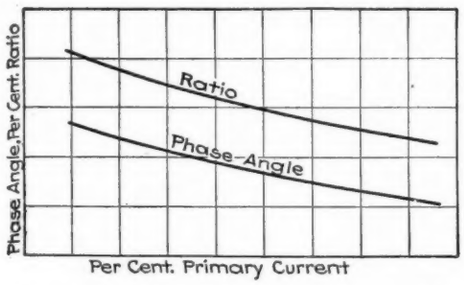


FIG. 6. PHASE-ANGLE AND RATIO CURVES

meter reading is 500 amperes, what is the value corrected for the current transformer error?

Assume 500 amperes to be 50 per cent rated current, and at this current the 25 volt-ampere curve, B, shows a ratio of 100.4 per cent. Then the corrected current is $500 \times \frac{100.4}{100} = 502.0$ amperes. It should be stated that this does not include the correction for the ammeter error.

The following table gives an idea of the volt-amperes required by various instruments. It is made up from data published by several manufactures.

Instrument	Volt-Amperes	Watt
Switchboard ammeter	4.0	3.6
Switchboard wattmeter (current coil)	4.0	3.85
Switchboard watt-hour meter (current coil)	1.5	0.7
Portable ammeter	4.5	4.0
Relay	18.0	10.0
Leads (30 ft. of No. 10 wire at 5 amp.)	1.5	1.5

For a circuit of several instruments the total volt-amperes is approximately the sum of the individual volt-amperes, and this value is close enough for ordinary work. To get the exact value of the instrument load, add separately the true watts and the reactive volt-amperes of all the instruments in the circuit. Square these two sums, add the squares, and extract the square root.

Phase Angle Not Important in Instruments that Indicate Current Only

The phase angle is of no importance in the case of instruments that indicate current only, such as ammeters and certain relays, but it does have an effect on the readings of instruments that depend on both current and voltage, such as wattmeters and watt-hour meters. Fig. 8 illustrates this. E_1 represents the voltage of a certain circuit, and I_1 the current in the circuit. The true power is measured by

$$P = E_1 \times I_1 \times \cos\ \theta \text{ or } E_1 \times Oa$$

But if a current transformer is used, the current in its secondary will be I_2, slightly in advance of I_1 and equal to it in length, (assuming that I_2 has been cor-

rected for ratio error). And the power measured in the secondary will be

$$P' = E_1 \times I_2 \times \cos(\theta - \alpha) \text{ or } E_1 \times Ob$$

which is evidently greater than $E_1 \times Oa$. The true value of power, therefore, corrected for current-transformer errors will be

$$P = kW \frac{\cos\theta}{\cos(\theta - \alpha)}$$

where

P = corrected value of power;
k = ratio correction factor = per cent ratio ÷ 100;
W = wattmeter reading;
θ = phase angle of the main power circuit;
α = phase angle of the instrument transformer (leading) for the particular value of primary current and instrument load in use.

A circuit composed of a switchboard ammeter, a switchboard wattmeter and a watt-hour meter is connected through 30 ft. of No. 10 wire to the current transformer represented by Fig. 7. If the ammeter reads 500, the wattmeter 825 kw. and the voltmeter 2,300 volts, what are the corresponding values corrected for transformer errors at 50 per cent load?

Referring to the table, we find the load caused by each instrument: Ammeter, 4 volt-amperes; wattmeter, 4 volt-amperes; watt-hour meter, 1.5 volt-amperes; leads, 1.5 volt-amperes; total, 11 volt-amperes.

From the curves we find that the ratio at 50 per cent primary current and 11 volt-amperes load will be 100.2

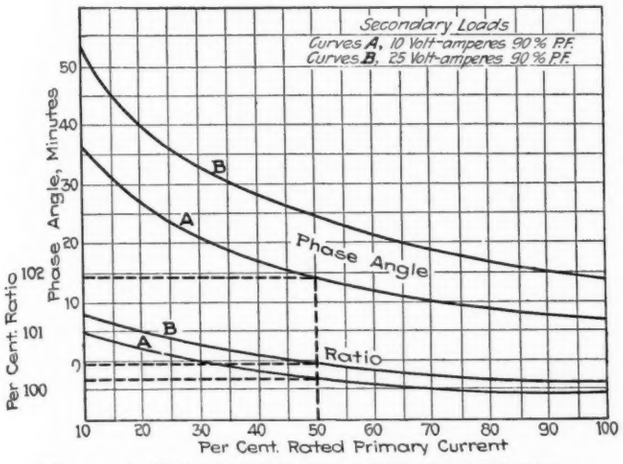


FIG. 7. RATIO AND PHASE-ANGLE CURVES FOR A TYPICAL CURRENT TRANSFORMER

per cent and the corresponding phase angle will be 14 minutes. The power factor of the circuit, $\cos\theta$, will be approximately

$$\cos\theta = \frac{825{,}000}{500 \times 2{,}300} = 0.7174$$

Therefore, θ, the angle whose cosine is 0.7174, is 44 deg. 9 min. 30 sec.; angle α equals 14 min.; then $\theta - \alpha$ equals 44 deg. 9 min. 30 sec. — 14 min. = 43 deg. 55 min. 30 sec., and the cosine of $(\theta - \alpha)$ is 0.7203. Therefore, $P = \frac{100.2}{100} \times 825 \times \frac{0.7174}{0.7203} =$ 823.3 kilowatts, and the current is $500 \times \frac{100.2}{100} = 501$ amperes. These values do not include corrections for instrument errors, but only for transformer errors.

The corrections due to current transformers are very small and may safely be disregarded for all except the most accurate work, if reliable current transformers are used and the instrument load is not excessive. There is a limit, however, to the instrument load that should be connected to a current transformer if accuracy is desired. This limit is entirely different from the limit imposed by heating of the coils, and generally it is smaller. The nameplate of current transformers is usually stamped to show the capacity in volt-amperes and also the load for which the transformer is compensated. The best accuracy is obtained when the instrument load is equal to the load for which the transformer is compensated.

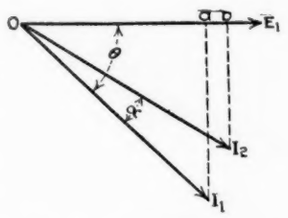


FIG. 8. CURRENT AND VOLTAGE RELATION

In changing the connections to a current transformer, care must be taken never to open the secondary circuit while current is flowing in the primary. To do so would cause all the primary current to become exciting current, since there would be no secondary current to be balanced by a "working current" in the primary. This would highly saturate the iron and, owing to the characteristics of the iron, the voltage induced in the secondary would not only be very high, but would also be very much peaked. Its maximum value under such conditions is usually high enough to be dangerous to life and sometimes high enough to puncture the insulation of the transformer. In addition to this the transformer may be permanently magnetized so as to impair its accuracy. If the insulation is uninjured, a magnetized transformer may be demagnetized and returned to normal conditions by putting a fairly high variable resistance, say 30 to 50 ohms, across the secondary, circulating about full-load current through the primary and gradually reducing the resistance to zero.

Pointers On Oil-Engine Operation

If the engine piston wedges or "freezes" in the cylinder, in most cases the lubrication of the piston is faulty. At times the "freeze" is a result of excessive piston expansion. Higher temperatures of the cooling water may be of assistance.

Some pistons, especially those without deflectors, expand at the top, scoring the cylinder. If a taper cut is taken off the circumference of the piston from the second ring to the top, the trouble is in most cases remedied.

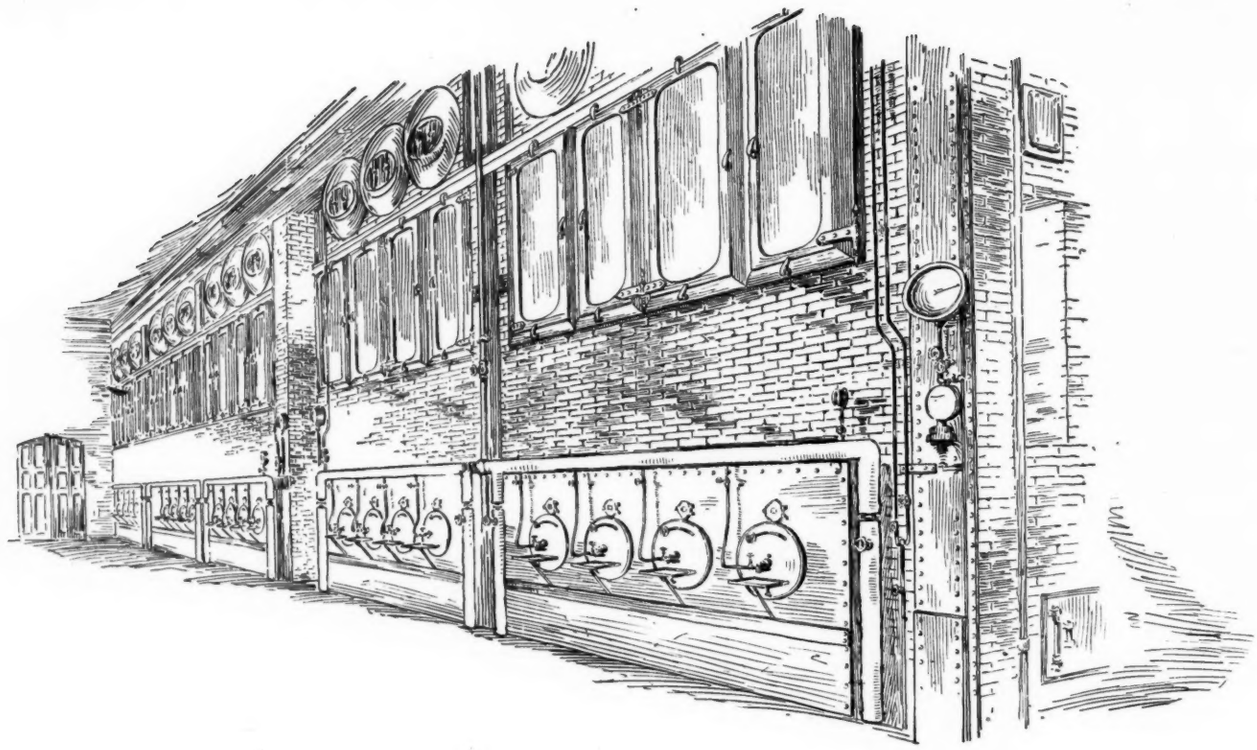
It is advisable to have the cooling water from the engine jacket discharge into an open funnel. In a closed system the circulation of water may be interrupted without the knowledge of the operator.

A piston water pump is the best type for small plants.

If unburned oil blows out the exhaust, either the atomizer leaks or the bulb is too cold.

Excessive amounts of lubricating oil will cause a smoky exhaust.

If an admission valve chatters at the beginning and end of the suction stroke, usually the spring has "set" and lost its elasticity. At times late timing of the valve produces chattering.



Efficient Handling of Fuel Oil—IV

By ALLEN F. BREWER

WHATEVER its type, the purpose of any oil burner is to atomize the fuel oil thoroughly, that it may intimately mix with, and present the greatest surface to, the air for combustion, and burn like a gas. Actual atomization occurs either within or at the top of the burner.

The general requirements for an oil burner are: Simplicity as to construction; should not leak or clog easily; adaptability to wide loads; subject to quick adjustment and control according to load; no restriction as to grade of oil used; economy of steam, air or pressure; no parts to wear out easily or quickly; no excessive noise or smoke; should give a steady flame without flickering; cleaning should be easily and cheaply done; no "blowtorch" effect to injure heating surfaces or settings; should be easily installed.

Atomization of the oil may be carried out by the burner in one of three ways—by the use of steam, compressed air or by mechanical pressure. The sketches of burner types shown cover only the basic principles, leaving out all unnecessary trade or patent details, etc. The various special designs of burners met with in practice will be found to include one of these basic ideas in practically every case. The steam and air types of burners may be further classified into inside and outside mixers, of either round or flat flame, and the air burners may be either high- or low-pressure. In the inside mixer the oil comes in contact with the atomizing agent within the burner, being atomized as it passes through the burner nozzle. In the outside mixing burner the mixing occurs essentially just beyond the nozzle, steam or air and oil passages usually terminating in the same vertical plane.

The general requirements of oil burners are designated, and the basic ideas that are included in the various designs of burners are discussed and illustrated. The burners are grouped under steam, air and mechanical atomization. Something is also said regarding the operation of oil burners. The next article will deal with pumping and heating fuel oil.

Whatever the type of mixer, the spray is essentially caused by expansion which occurs when the atomizing agent, under pressure, emerges from its particular orifice to mix with the oil. Basic sectional views of such burners are shown in Figs. 1, 2, 3, 4 and 5.

In Figs. 1 and 2 mixing occurs outside the burner, the oil either drooling or dripping from the lip of the oil duct onto the spray of high velocity, expanding steam or air, which effectively atomizes it. As shown in Fig. 2, the oil duct is above the steam. This principle has been inverted by a number of manufacturers of steam burners, the oil oozing up to meet the steam and thereby being swept off the lip at right angles to its flow by the latter (see Fig. 3). A certain amount of ejector action is obtained by this arrangement of mixing, which draws the oil toward the lip of its duct, thus decreasing the amount of pumping pressure necessary for the oil. Figs. 4 and 5 show basic sectional views of inside mixing burners. Fig. 4 requires no ex-

planation. The burner in Fig. 5 is based on the principle of the steam injector, the steam drawing the oil from the oil duct, thus doing away with the necessity of as high oil pressure. In such a burner the mixture of oil and steam travels with increasing velocity to the throat, or narrowest part *C*. From this point rapid expansion occurs, which atomizes the oil. The steam consumption may generally be assumed at 2 per cent of the total produced for atomization and 2 per cent of the total produced to run the pumps, heaters, etc.

The use of air as an atomizing agent is chiefly confined to metallurgical work where a short, intense flame is desired. There is little to choose in economy between steam or air as an atomizer, the amount of steam ultimately used for the burner or air blower or compressor being practically the same. The blower or compressor, however, involves additional first expense for equipment, piping, etc., and requires more care.

In the case of air-jet burners, whether they are high- or low-pressure depends on the air pressure used. The low-pressure burners operate at about two pounds air pressure and are more economical; for such burners air blowers are required. In the high-pressure burner system air compressors are necessary, since air is used in the neighborhood of forty to fity pounds pressure.

Flat Flame Best for Stationary Boilers

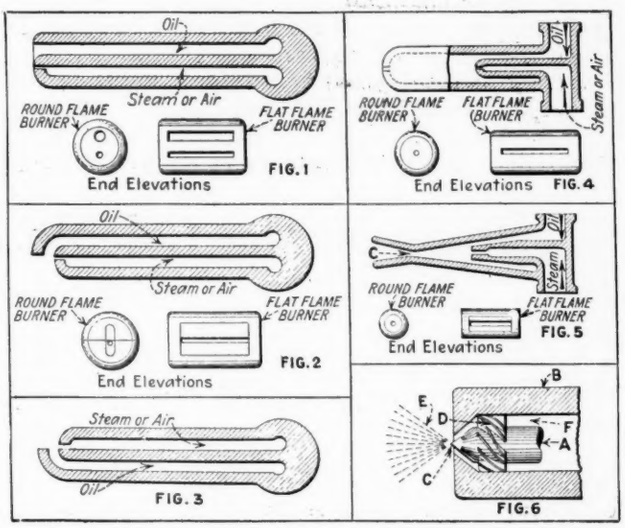
A flat flame is generally best for stationary-boiler work, since it gives the greatest surface for heat radiation, enables a more even distribution of the gases of combustion and requires fewer burners per furnace. The advantages of steam burners are: Simplicity of equipment; less intense heat in furnace, and longer flame. The disadvantages are: The use of steam reduces the quantity of heat available, owing to the tendency to carry the latter up the stack, thereby reducing the possible temperature in the furnace; the quantity of steam required makes additional water evaporation necessary; priming in the boiler and water in the steam will affect the flame, even sometimes extinguishing it; steam displaces air in the combustion chamber, and fine control of the flame is a difficult matter.

The advantages of air burners are: Best for metallurgical work; advantageous when the pipe lines for the oil and atomizing agent are of considerable length, and the burners are installed at a number of locations distant from the boiler house; less likelihood of water in the air than in the steam. The disadvantages are: The flame is so short and so intense as to damage the ordinary furnace setting, brickwork and boiler tubes; they are expensive to install.

Mechanical Atomization

With a burner of the mechanical-pressure type the idea is to give the oil a rapid whirling motion within the burner tip. This may be done in one of three ways: By forcing the oil under pressure through a helical duct; by feeding it tangentially into a circular chamber, to exit through a central outlet; by forcing it through a rapidly revolving disc, which is made to revolve by the pressure of the oil.

These principles all involve atomizing by a combination of pressure plus centrifugal force, the spray emerging from an orifice in the form of a cone. The rotation of the oil takes place entirely within the burner; the spray does not revolve. The basic design of such a burner is shown in Fig. 6. It consists of a cored-out tube *B* in which the oil passageway *F* is tapered to an orifice in the end, through which the oil spray emerges. In general this orifice is never greater than one-quarter of an inch in diameter. Within *B* is a rod *A*, its end tapering to a point *C* at the orifice of *B*. Just back of the taper is a set of slanting vanes *D*, which serve to deflect and break up the oil as it is forced through them. As a result the oil reaches the orifice in a whirling condition, partly atomized. As the oil passes through the orifice at high velocity, atomization is completed by expansion. The path of the spray after it leaves the burner orifice is shown by the diverging lines *E*. While it is not meant to imply that this constitutes the construction of any actual burner on the market today, yet it is well to state that the principles



FIGS. 1 TO 6. SECTIONAL AND END VIEWS OF OIL BURNERS

Fig. 1—Steam or air burner, drooling type. Fig. 2—Steam or air burner, atomizing type. Fig. 3—Another atomizing type; all outside mixing. Fig. 4.—Oil burner, inside mixing. Fig. 5.—Injector type of oil burner, inside mixing. Fig. 6.—Mechanical atomizing oil burner.

shown cover the most essential features of a successful mechanical-pressure burner.

Its advantages are that it permits the return to the boiler as feed water all steam used for pumps, heaters, blowers, etc., a valuable feature in marine work or plants where suitable water is scarce or hard to obtain, and it has a wide range of capacity. Its disadvantages are: The excessive equipment required; the tendency of the flame to "blowtorch," necessitating care in the installation, and frequently alteration of the furnace; owing to the small diameter, the orifice will tend to clog with carbon, dirt, etc., necessitating frequent and periodic removal for cleaning.

Operation of Burners

When burners are not in use or when starting, be sure that oil does not flow prematurely and drip to the floor of the furnace before ignition. Explosive vapors will surely result, which may lead to explosion within the furnace when the lighting-off torch is introduced.

Under normal operation use enough burners to insure a solid sheet of flame across the furnace, if possible. This will prevent air for combustion passing up the stack without fulfilling its purpose, and the localization of heat on any part of the brickwork or heating surfaces. Burner installations should be such that flames

from individual burners will not overlap or impinge to any extent on the side walls. Most even heating is gained by such construction.

A burner is less efficient when forced than when operating normally. Hence, find out the horsepower rating of the burners and use enough of them to produce the horsepower under which the boiler is normally operated.

Oil flow of steam or air burners is maintained by means of the needle valve, or burner valve in the oil line. In mechanical burners it is maintained by means of pump pressure or, preferably, by an independent control valve on the burner. In many mechanical atomizing installations, where more than slight control of oil is necessary, owing to sudden material increase or decrease of the load, the control is carried out by cutting burners in or out of service. This is frequently an unsatisfactory practice, as the burners are liable not to relight readily owing to carbonization; as a result changing and cleaning may be necessary, involving loss of time and extra labor. The ideal burner, whatever its type, should be freely flexible; that is, capable of adjustment to give a full, medium or low fire instantly when desired, without altering the oil pressure or changing the flame materially.

Sufficient oil pressure must be maintained at all times to overcome the back pressure of the steam or air. The lighter the oil fired the less chance of such back pressure, hence the less oil pressure required. Only enough oil pressure is necessary with such burners to insure a constant and even flow through the piping and burners. Piping bends should be kept to a minimum. Avoid sharp ells, using wide bends when necessary.

When not in use, keep the burners clean, free from dust, corrosion, etc. Remove from the line, if possible, clean thoroughly with kerosene, cover with a coating of lubricating oil or light grease, store in a dry place.

With a steam or air atomizing burner system, a bypass with a valve should always be installed between the steam or air and the oil lines to afford means of blowing out and cleaning the oil passageway in the burner; the latter should be done frequently to prevent carbonization. The burner piping should be fitted with unions on either side of each burner to facilitate the removal of the latter when necessary.

Notes on the Calculation of Blower Systems

By JOHN L. ALDEN

When the writer was gaining his first experience in the industrial application of low-pressure air he found it difficult to get accurate engineering data on centrifugal fans and fan systems. Engineering textbooks contain but little information on any part of the subject other than the flow of fluids. Few of the fan catalogs contain engineering information of value, and many of them are misleading. This has resulted in an air of mystery being thrown around the engineering side of many of the commonest industrial installations, such as dust-collecting systems, pneumatic conveying systems, etc. The result is that the use of air for various purposes has not been as general as it should have been. It is the intention, therefore, in this article, to outline the method to be followed in carrying out the power calculations of a fan system and to give in convenient form the data on which the calculation is based. This material is not original; the writer has used it in his work and has collected it from various sources, changing the form for the sake of convenience.

The fan is a machine the purpose of which is to convert the energy of the motive power into the potential and kinetic energy of a moving air column. Therefore, if the amount of work to be accomplished and the efficiency of the blower are known, the power required to drive it can easily be determined. The output horsepower of the fan may be expressed as

$$hp_o = QdH/33000, \qquad (1)$$

in which

Q = Volume of air in cu.ft. per min.;

d = Density of the air at the temperature and pressure within the fan;

H = Total head produced by the fan in feet of air at density d.

The input power to be supplied by the motor, is the output power just obtained divided by the efficiency of the fan.

$$hp_i = \frac{hp_o}{e} \qquad (2)$$

where e is the fan efficiency.

In the following discussion the standard condition of air will be taken as 60 deg. F., 29.92 in. barometer, and dry air. Since H, the head measured in feet of air, is an inconvenient unit to use, we may transform this air column to an equivalent column of water at the standard temperature. If p equals the equivalent water column in inches, $dH = 5.21\ p$, and

$$hp = 0.000158\ Q\ p. \qquad (3)$$

Combining equations (2) and (3),

$$hp_i = \frac{0.000158\ Qp}{e} \qquad (4)$$

Table I gives the range of fan efficiencies for the types ordinarily encountered. These are test figures and will be found quite reliable. The second column of figures in this table is given as a warning against overloading a fan. The efficiency falls off rapidly after a certain point is reached, and the extension of a duct system beyond the normal capacity of a fan results in a great increase in power.

TABLE I. FAN EFFICIENCIES

Type of Fan	—Efficiency, per Cent— Rated Capacity	Maximum Capacity
Paddle wheel, 6-8 blades	40–45	20–27
Paddle wheel, 12–16 blades	43–52	20–32
Multib'ade, 30–64 blades	48–60	22–41
Pressure blowers	55–70	25–40
Turbo-compressors	65–80	29 55

Formula (4) is expressed in chart form in Fig. 1. Having given the volume, pressure and fan efficiency, it is required to find the power to drive the blower. Connect the volume on the right-hand scale with the pressure at the left. Connect the point where this line crosses the ungraduated reference lines RR in the middle of the chart with the value of the efficiency on the efficiency scale. The intersection of this line with the horsepower scale gives the input horsepower to the fan for the standard conditions of 60 deg. F., 29.92 in. barometer, and dry air. For a direct-connected motor the chart figures give the required motor output. For a belt or chain drive add 5 per cent and for a geared drive add 10 per cent to the motor capacity. From formula

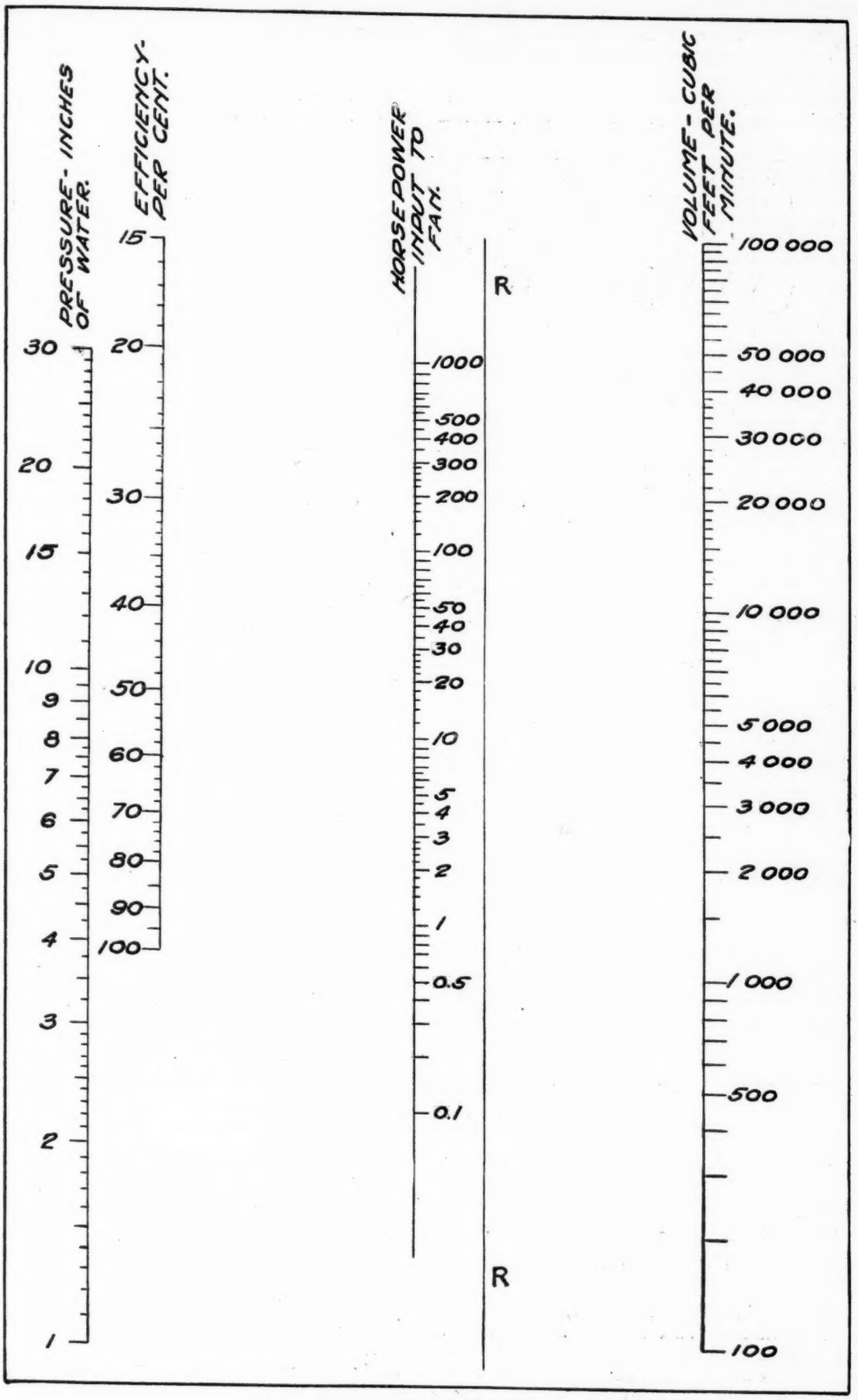


FIG. 1. POWER CHART FOR AIR BLOWERS

(1) it is plain that any circumstance affecting the air density affects the power in the same manner. Thus the temperature, barometric pressure, altitude, humidity and the compression of the air by the fan modify the power requirements. The power is increased in proportion to the increase of density. The following changes

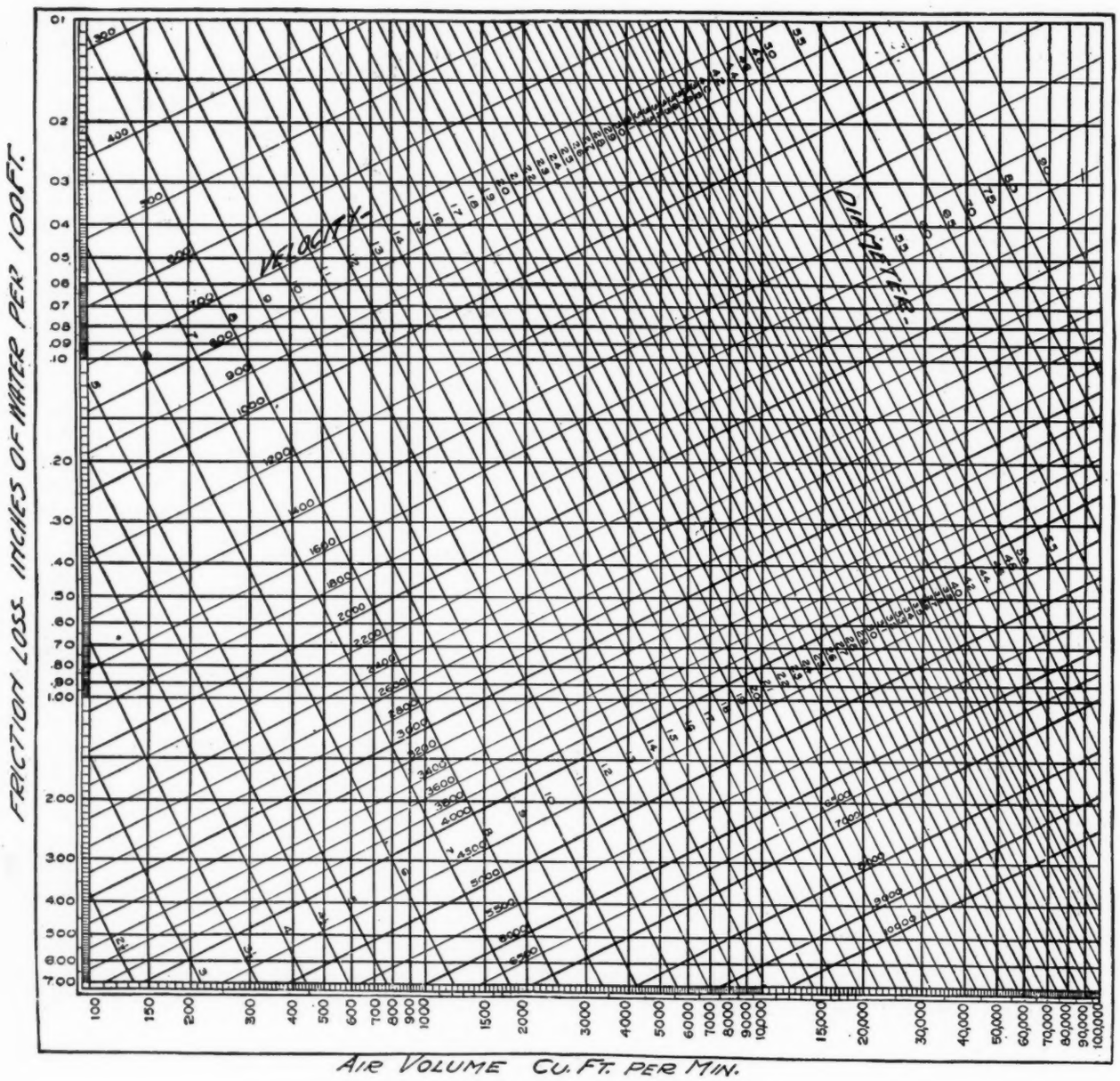


FIG. 2. FRICTION CHART FOR AIR PIPING

represent an approximate increase in power of 1 per cent over the standard conditions:

An increase in temperature of 5 Deg. F.

An increase in barometric pressure of 0.3 in. of mercury.

A compression of 4 in. of water over atmospheric pressure.

The effect of altitude is to decrease the power about 1 per cent for each 275 ft. for altitudes below 5,000 ft. and about 1 per cent for each 300 ft. above that. The reduction in power due to moist air should be obtained from hygrometric tables by comparing the densities of moist and dry air. For ordinary ventilating or dust-collecting design work most of the corrections may be neglected. In fan testing, however, account must be taken of temperature, barometric pressure, humidity and the compression.

The volume of air to be used in figuring the horsepower is determined from hygienic requirements for ventilating work, by combustion calculation for forced-draft work and by the product of the pipe area and the velocity necessary to carry the material in dust-collecting and conveying work. The pressure developed by the fan is the sum of the following:

1. The pressure necessary to cause flow through the ducts at the desired velocity—velocity pressure.
2. The entry loss at the suction opening.
3. The friction losses in the suction and discharge pipes.
4. Loss through the back pressure of dust collector, dust bin, heater, etc., or through any special resistance in the system.

The velocity produced by a given pressure at standard conditions, without loss, is

$$v = 3980\sqrt{p}, \qquad (5)$$

where v is in feet per minute and p is the velocity pressure in inches of water.

The entry loss at the opening of a straight suction pipe is about 25 per cent of the velocity in the pipe. The corresponding loss through the open inlet of an ordinary fan is about 35 per cent of the velocity through the inlet. In other words, to produce the desired rate of flow through the inlet opening, a suction must be created equal to 1.25 and 1.35 times the desired velocity pressure. The friction loss through the various pipe lines may be taken from the chart in Fig. 2. This chart was constructed from test figures on smooth metal pipes, and to allow for ordinary roughness, rivet heads, solder, laps and dents, 50 per cent should be added. For moderately smooth concrete ducts and plastered brick ducts, add 100 per cent. The loss through 90 deg. elbows is approximately as given in Table II, the friction being expressed as the number of diameters of straight pipe equivalent to one elbow. The back pressure of dust collectors varies between $\frac{1}{16}$ and 10 in. of water. A well-designed collector, properly installed, should impose less than one inch of back pressure. However, the majority of collectors as actually installed produce back pressures ranging from 1 to 2½ in. of water. A fair average of current installations would be 1½ inches.

TABLE II. FRICTION LOSS IN ELBOWS

Throat radius diameters	½	⅝	¾	1	1½	2	3	4
Equivalent length of straight pipe, diam.	67	30	16	10	6	4.3	4.8	5.8

The following example is typical of the ordinary procedure: A pneumatic conveying system is to handle air at 40 deg. F. through a 20-in. pipe 290 ft. long with three elbows. To carry the material in suspension, a velocity of 4,500 ft. per min. is required.

Volume = 2.18 × 4500 = 9800 *cu.ft. per min.*

From Fig. 2 the friction loss per 100 ft. is 1.1 in. of water. The elbows have a throat radius of two diameters, making the equivalent length 3 × 4.3 × 1.67 = 22 ft. The total pipe length is then 312 ft., and the friction loss is 3.12 × 1.1 = 3.43 in. Adding 50 per cent we have 5.15 in. The velocity head is $\left(\frac{4,500}{3,980}\right)^2 = 1.28$ in. The entry loss is 0.25 × 1.28 = 0.32 in. The total pressure, then, is 5.15 + 1.28 + 0.32 = 6.75 in. of water. The output horsepower of the blower handling standard air is 10.5 hp. as taken from the chart or equation (4). Add, for temperature correction, 4 per cent and the output horsepower becomes 11 hp. If the fan is a slow-speed exhauster with 16 blades, forward curved, the efficiency will be about 50 per cent, making the input power 22 hp. If belt-driven, the motor must supply 23 hp., and a 25-hp. motor should be installed.

New Zealand now has in operation 71 local electric supply plants having a total capacity of 45,805 kw. Several of these plants are being changed to the three-phase 50-cycle system, which the New Zealand Government intends to standardize. A great many new developments are being proposed, and there appears to be an opening there for American electrical machinery and supplies.

P. & K. Air-Pressure Controlling Valve

This device, known as the P. & K. remote-control air-pressure controlling valve, is designed for use in regulating the forced- or induced-draft fan controlling the air supplied to boiler furnaces and for controlling the predetermined flow of air in heating and ventilating systems. It is made by the Pitts & Kitts Manufacturing and Supply Co., 50 Park Place, New York City. The object of this valve is to secure better combustion, more sensitive control and automatic regulation of the speed of the engine driving the fans and to maintain a constant predetermined air pressure in the air duct, resulting in improved firing conditions and in a uniform rate of combustion. Fig. 1 is an exterior view of the controlling valve. In Fig. 2 is shown its method of operation. When the valve has been installed, close the valves *B*, *C* and *D*, after which the fan engine is started. Next adjust the weights on the lever of the valve *V* until the air in the main duct registers the lowest pressure desired, say ½ in. Then gradually open the valve *C*, bleeding some of the air out of the 1-in. air line until the valve *D* responds and the fan increases the air pressure in the main duct, the valve *L* being opened.

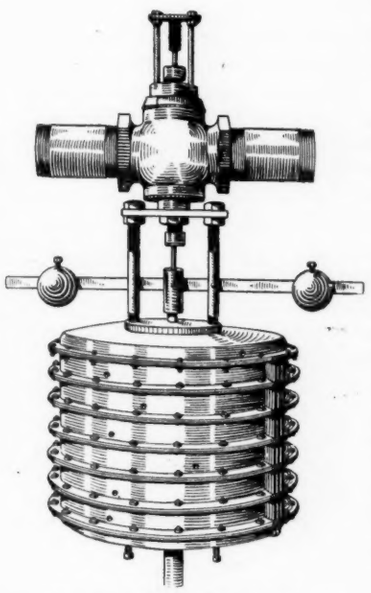


FIG. 1. EXTERIOR VIEW OF PRESSURE CONTROLLING VALVE

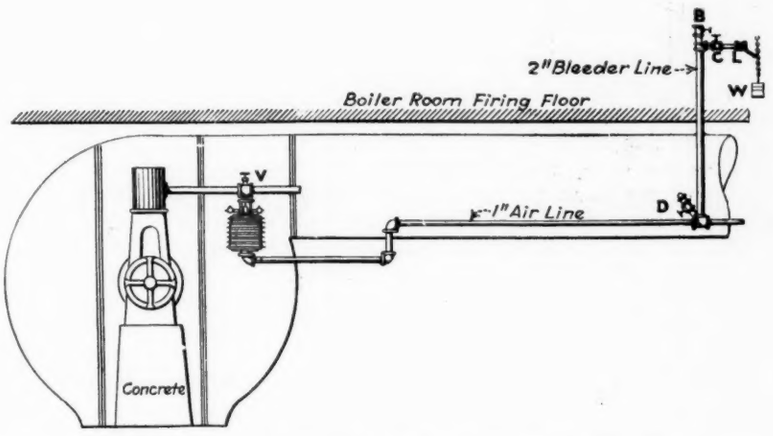


FIG. 2. ARRANGEMENT OF VALVES AND PIPING

The steam pressure, going up, operates the damper regulator and closes the valve *L;* the valve *V* will respond and reduce the speed of the fan, thus causing the air pressure to drop. When the steam pressure has dropped ½ lb., the damper regulator will operate to open the valve *L* and the valve *V* will respond to increase the speed of the fan.

Standard Unit Adopted by the Refrigerating Industry

By F. E. MATTHEWS

SO IMPORTANT is the movement toward standardization in the refrigerating industry, the first tangible fruit of which has been the adoption of a basic unit of measurement, that a review of the work toward this end, expended on both sides of the ocean, is considered in order.

The history of the movement in the United States seems to have begun when Gardner T. Voorhees introduced the subject at the Southern Ice Exchange in February, 1903. A committee of five was appointed by the association to consider the subject and report. Similar committees were appointed by the Southern Ice Manufacturers Association, the Indiana Ice Manufacturers and the Western Ice Manufacturers Association, all in 1903.

In May, 1903, the Ice Machine Builders Association agreed that the capacity rating of refrigerating machines should be figured on a basis of the evaporation of 27.7 lb. of anhydrous ammonia per hour (0.462 lb. per minute) at a pressure of 15.67 lb. gage (corresponding to a saturation temperature of 0 deg. F.) and 185 lb. gage condensing pressure. Under these conditions the refrigerating machine would produce a refrigerating effect equivalent to that of the melting of one ton (2,000 lb.) of ice in 24 hours. This was an important step for the advancement of the industry.

After seventeen years of deliberation of refrigerating engineers of two engineering societies, the American Society of Refrigerating Engineers unanimously adopts recommendations of joint committee definitely fixing the "Standard Unit of Refrigeration" as the equivalent of the absorptiou of 288,000 B.t.u. of heat. Further recommendations by the joint A. S. M. E. and A. S. R. E. committee, pertaining to "Basis for Owner's Rating" and "Rules for Conducting Tests" will follow in due course of time.

For some time after the subject was launched, it precipitated a lively discussion and gave rise to a number of papers, published in the technical press and read before the American Society of Mechanical Engineers, including a lengthy one by the writer, here mentioned because of the novel suggestion made to parallel what had been done in steam practice and employ as a starting point the evaporation of the refrigerant under atmospheric pressure "from and at —28½ deg. F." in the case of anhydrous ammonia similar to "from and at 212 deg. F. in the case of steam." (See Trans. A. S. M. E., Vol. XXVI.)

At the December, 1903, meeting of the American Society of Mechanical Engineers a committee was appointed by that society at the suggestion of Prof. S. A. Reeve to suggest a standard tonnage basis for refrigeration. This committee, reporting at the December meeting of the society in 1904 and limiting its considerations to refrigerating machines "which perform refrigeration by the evaporation of a refrigerating fluid," divided the work under two main heads: Selection of units for measuring refrigerating effect, and selection of a standard set of conditions under which a refrigerating machine, whatever its type, shall be run, in determining its commercial tonnage capacity.

The unit adopted to measure the cooling effect of the refrigerating machine as published in a preliminary report of the committee "is the heat required to melt one pound of ice, which is 144 British thermal units." The unit for a ton (2,000 lb.) of ice melting capacity is therefore 288,000 B.t.u.

The commercial tonnage capacity of a refrigerating machine was defined as "the refrigerating effect expressed in tons of ice-melting capacity produced by a machine in 24 hours when running continuously under the standard set of conditions." For the "standard set of conditions" it was recommended that "the temperature of the saturated vapor at the point of liquefaction in the condenser be 90 deg. F., and that the temperature of evaporation of the liquid in the refrigeration be 0 deg. F." (Par. 7 of report.) In order that there should be no doubt as to the method of application the following statement was also made in the report: "The commercial tonnage capacity of any refrigerating machine using liquefiable vapor is based upon the actual weight of refrigerating fluids that is circulated between the condenser and the refrigerator and that is actually evaporated in the refrigerator. (Par. 9 of report.) Under the conditions specified in Par. 8 and 9, twenty-five lb. of anhydrous ammonia per hour must be evaporated in the refrigerator for one ton of commercial tonnage capacity.

In the fall of 1908 the American Society of Refrigerating Engineers authorized President Penny to appoint a committee of five to co-operate with a similar committee of like number of the American Society of Mechanical Engineers. Much work was done by the joint committee, and various findings were promulgated, but nothing was adopted by either society. Realizing the disadvantages of not having at least a generally adopted unit of refrigeration, members of the main joint committee suggested referring the question of the "Standard Unit" and "Owner's Method of Determining Rating" to a special committee not laboring with the subject of test code. The appointing of this special committe was authorized by the A. S. M. E. council May 24, 1920, and a similar committee was appointed forthwith by the A. S. R. E. The findings of this special committee were unanimously adopted at the December, 1920, meeting of the A. S. R. E. The same report was submitted to the A. S. M. E. and published for criticism and discussion pending action at the spring meeting of the society in 1921.

By the adoption of the recommendations of this committee the American Society of Refrigerating Engineers fixed (A) a standard ton of refrigeration as 288,000

B.t.u., (B) the rate of heat absorption for a commercial ton of refrigeration as 200 B.t.u. per minute (equivalent to 288,000 B.t.u. per 24 hours), and (C) the standard rating of a refrigerating machine, using a liquefiable vapor as the number of standard commercial tons of refrigeration it performs under certain adopted inlet and outlet pressures defined as those corresponding to saturation temperatures of 5 deg. F. (—15 deg. C.) and 86 deg. F. (30 deg. C.) respectively.

British Engineers Submit Report

In the meantime European engineers, witnessing the confusion resulting in America from the promulgation of many, and acceptance as official of no standards, began to give the matter serious consideration, and the Institution of Mechanical Engineers, London, was submitted a report by its Refrigeration Research Committee in October, 1914. The work of the committee included the following subject: (1) "To consider what standard, if any, should be used for the practical rating of refrigerating machines, as a means of expressing the amount of refrigerating effect which the machine is capable of producing under specified conditions such as occur in ordinary practice." "This involves two points; namely, the unit in which refrigeration is to be measured and stated and the temperatures between which a machine should, for the purpose of rating, be assumed to act."

The committee recommended: (1) That the refrigeration produced by a refrigerating machine be expressed in calories per second. This unit is equivalent to 342.860 B.t.u. per day for twenty-four hours. (2) That the refrigeration may be started for particular conditions. (3) The "standard conditions" recommended were the following temperature limits:

For the brine { Upper limit 0 deg. C. (32 deg. F.)
Lower limit —5 deg. C. (23 deg. F.)

For the cooling water { Upper limit 20 deg. C. (68 deg. F.)
Lower limit 15 deg. C. (59 deg. F.)

For direct expansion, evaporator temp., —10 deg. C. (14 deg. F.)

The second division of the work as outlined by the English committee is to consider what theoretical cycle of action should be adopted as a standard for comparison with the actual performance of a refrigerating machine working under any conditions, as a means of judging how nearly the real action approaches the ideal. The use of such a cycle would lie in the analysis of tests and the criticism of actual performances, also in the design of refrigerating plants, taking account of ratios (determined by experience) between real and ideal performance in machines of given types.

Value of Unit if Adopted

Believing that only good can result from knowledge of the English viewpoint, it may be mentioned that in the discussion that followed the presentation of the Institute of Mechanical Engineers report, F. A. Wilcox, member of the Refrigeration Committee, stated that the unit if adopted would not be of any use except to those who had sufficient knowledge to be able to say how many units of refrigeration would be required for any particular installation.

In this connection one is tempted to suggest that the American ton should prove more valuable since it requires less technical knowledge to determine how much ice the prospective customer is using than how many calories per second he will require.

Wilfred Stakes raised the point, which has proved an almost insurmountable barrier to the adoption of a standard set of conditions in the United States, that there is a difference of opinion as to what are the average conditions of "ordinary practice." As a matter of fact it makes little difference what temperatures are adopted as standard aside from convenience in manipulation and temporary confusion pending their general adoption, such as has been pointed out by our English friends.

The following are the standards adopted by the Amering Society of Refrigerating Engineers Dec. 7, 1920:

1. The Standard of Refrigeration is 288,000 B.t.u.

2. The Standard Commercial Ton of Refrigeration is the extraction of heat at the rate of 200 B.t.u. per minute.

3. The Standard Rating of a refrigerating machine using liquefiable vapor is the number of standard commercial tons of refrigeration it performs under the following adopted refrigerant pressures: (a) The inlet pressure is that which corresponds to a saturation temperature of 5 deg. F. (—15 deg. C.). (b) The outlet pressure is that which corresponds to a saturation temperature of 86 deg. F. (30 deg. C.).

Simplicity of the A. S. R. E. Standard Unit

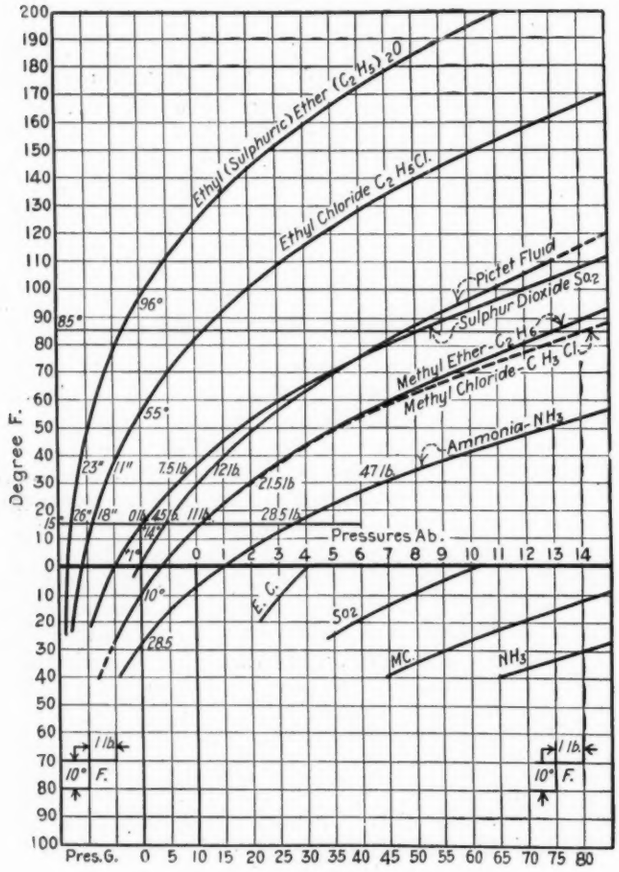
The value of a standard unit to the refrigerating or any other industry depends directly on the extent to which it is employed. It must accordingly be of maximum simplicity and of such a nature as to be readily visualized by the user. To the consumer of ice, actual or prospective, there is nothing that can have a more simple, definite and graphical meaning than a pound or a ton of ice. To the scientist as well as to the engineer and to most users of ice, there is no question regarding the constancy of the cooling effect realized from the melting of a pound or a ton of ice. The latent heat of ice, which within reasonable limits is found to be independent of its degree of purity, has now been definitely determined by the United States Bureau of Standards as within a very small fraction of one per cent of 144 B.t.u. (143.5 B.t.u.). Nothing can be more simple, practical and scientifically definite than the standard unit of refrigeration just adopted by the American Society of Refrigerating Engineers, the ton of refrigeration equivalent to the absorption of 288,000 B.t.u., based on the melting of one ton (2,000 lb.) of ice having a latent heat of 144 B.t.u. per pound.

What this actually amounts to, to the busy engineer can be best illustrated by a practical example. Given 10,500 sq.ft. of insulated wall having a heat transmission of 0.003⅓ B.t.u. per sq.ft. per degree F. difference in temperature per hour, and assume a difference in temperature of 60 deg. F. The B.t.u. to be removed from this source would be $10{,}500 \times 60 \times 0.003\frac{1}{3}$, or 2,100 which, divided by 200 B.t.u. per minute equivalent to a standard ton, gives immediately 10.5 tons of refrigeration, the amount of refrigeration duty to be performed to remove the heat.

Limitations of Former Attempts To Establish Standards

Most former attempts at establishing standards having to do with machine capacity have been limited not only to those machines employing a liquefiable vapor as in the present case, but also to machines employing anhydrous ammonia as the working medium. It will be noted with satisfaction that the A. S. R. E. standards

are independent of the working medium, since they get the working range by defining temperature instead of pressures. Thus it is apparent from the group of temperature-pressure curves in the diagram representing all the well-known low- and medium-pressure refrigerants, that 5 deg. F., the standard fixed for the suction gas, corresponds to a "saturation pressure" of 27 in. of vacuum in the case of ethyl ether, 20½ in. of vacuum in the case of ethyl chloride, 7 in. of vacuum in the case of sulphur dioxide, 1 lb. gage pressure in the case of Pictet fluid, 6 lb. gage pressure in the case of methyl ether and methyl chloride and 19 lb. gage pressure in the case of ammonia. Similarly, 86 deg. F., the standard



PRESSURE-TEMPERATURE DIAGRAM OF REFRIGERANTS

fixed for the discharge gas, corresponds to a saturation pressure of 6 in. of vacuum in the case of Pictet fluid, 51½ lb. in case of sulphur dioxide, 82½ lb. in the case of methyl ether and, although falling beyond the range of the curves here shown, 8,083 lb. and 154 lb. in the case of methyl chloride and ammonia respectively.

In the case of carbon dioxide, the working pressure of which falls entirely outside of the chart, the suction and discharge corresponding to the foregoing temperature standards are about 270 and 1,035 lb. gage respectively.

It will be noted that no attempt is made to define accurately the quality of the gas in the case of either the intake or the outlet. While it is conceded that the condition as regards saturation, supersaturation or superheat will affect the performance of the machine, the disadvantages that the omission of the factor will involve are incompatible with the complications that an attempt to introduce it would involve. Adverse conditions of superheat in the intake, for example, are to be avoided for the same obvious operating reasons that a "superheated" bearing is to be avoided. The vender of the machine will appreciate the value of operating under proper conditions in these respects and will, for the reputation of his machine, endeavor to impart that knowledge to his customer.

Failure to introduce this factor in the specification of standards should not be interpreted to mean that the condition of the gas should not be noted and recorded in case of tests, since it will be both interesting and essential to a complete analysis by means of Mollier diagrams. Another reason why the specification of conditions of gas should not be introduced is the enormous difficulty it would involve in cases that will undoubtedly frequently arise when attempt will be made to duplicate, exactly under test, the prescribed conditions.

Difficulty of Maintaining Three Factors Constant

The task of simultaneously maintaining three factors constant and of a predetermined value is almost infinitely greater than when only two specified pressures are involved. As a matter of fact the profession realizes the absolute practical impossibility of exactly duplicating any set of standard conditions for the considerable time required for tests, even when, as in the case of the conditions adopted, only two temperatures or equivalent pressures are involved.

This condition granted, the necessity for tables for converting the results obtained under the actual into the equivalent under standard conditions is apparent. Such factors have been promised by the A. S. R. E. committee. These factors, however, can deal primarily only with thermodynamical variations such as the difference between the latent heats and the heats of the liquid under standard and test conditions. A table of such correction factors applicable just as are "factors of equivalent evaporation from and at 212 deg. F," used in steam practice, was prepared and presented for this purpose by the writer in his paper, "Standard Unit of Refrigeration," already referred to.

Other tables may be prepared which will indicate something of the variable effect of clearance in a given compressor, though, as Sir Alfred Ewing (chairman of the I. of M. E. Committee) has stated, "For the full rating of a machine it would be necessary to have a family of curves giving the means of expressing the performance for all temperatures, both at the top and at the bottom of the range, but it is better than nothing to have a definite figure of performance for one particular set of temperature conditions, and that was as far as the committee had gone in their attempt at rating."

Engineers who have had occasion to determine variations of performance with varying suction pressure and constant head pressure and with constant suction pressure and varying head pressure, even for a single refrigerating machine, know something of the work involved in the production of the "family" of curves just mentioned, which would be similar in appearance to those employed to show the characteristics of electric generators and motors and will be forthcoming only when the refrigerating industry shall have more nearly approached the degree of refinement attained by the electrical industry.

In conclusion it may be said that the new basis for rating is applicable to the "refrigerating machine" de-

fined as "the compressor cylinder of the compression refrigerating system of the absorber, liquor pump and generator of the absorbtion refrigerating system." Such limitation was necessary because the remainder of a refrigerating plant is even more varied in structure and operation than the "refrigerating machine" proper, and it is not advisable to include in a basis for determination of the rating of one part of the complete plant any element pertaining more intimately to some other member, such as a condenser, which has a basis for rating all its own.

Assuming, for the sake of comparison with the figures given the old preliminary A. S. M. E. report, that the temperatures in both cases are those of the liquid before the expansion and the gas entering the compressor, the amount of ammonia per minute required per ton of refrigeration would be expressed,

$$\textit{Pounds ammonia per min.} = \frac{200}{L - (h_1 - h_2)}$$

in which 200 is the B.t.u. per minute equivalent of 288,000 B.t.u. for 24 hours, one standard ton; L is the latent heat of vaporization at the lower temperature; and h_1 and h_2 are the heats of the liquid at the upper and lower temperatures respectively.

Temperatures mentioned in tentative report, 0 deg. F. and 90 deg. F.:

$L = 568.7$ $h_1 = 143.5$ $h_2 = 42.9$.

Adopted temperatures, 5 deg. F. and 86 deg. F.:

$L = 564.9$ $h_1 = 138.9$ $h_2 = 48.3$.

Substituting these values in the equation gives:

Pounds of ammonia per min. (old basis),

$$\frac{200}{568.7 - (143.5 - 42.9)} = 0.42725$$

Pounds ammonia per min. (standard basis),

$$\frac{200}{564.9 - (139.9 - 48.3)} = 0.4216$$

The amount of ammonia per hour under these two conditions would be, respectively, 25.635 and 25.296 lb.

That is, under the adopted standard, the rating of refrigerating machines will be about 1.3 per cent lighter than under the old suggested temperature levels.

New Geared Turbine Set

The steam-motor gear unit is designed to eliminate the trouble arising from distortion of the alignment of the bearings, due to high and varying temperature existing at the turbine end, and the uncertain behavior of metals when subjected to varying temperatures. To overcome the last possibility of foreign influences reacting on the gears, the turbine wheel is mounted on the gear-pinion shaft. The driven gear, which is mounted on the shaft driving the pump or generator, as the case may be, is in a housing with the pinion gear. The gear housing is divided horizontally along the center line of the pinion and gear shafts. An oil reservoir in the bottom of the housing has a capacity sufficient for the necessary lubricating oil used by the forced-feed system.

In general the steam-motor gear unit, manufactured by the Steam Motors Co., Springfield, Mass., consists of a turbine element mounted directly on the gear housing, making one rigid frame for the turbine and gear. The turbine wheel is mounted directly on the pinion shaft, which in turn is supported by two bearings. The turbine is of the single-pressure multi-velocity stage impulse type. The steam, after passing through the buckets of the first wheel, is redirected by a set of stationary guide blades to a second wheel, thereby absorbing as far as practicable, all the kinetic energy in the steam, after which it is exhausted through the exhaust connection. The turbine wheel consists of steel plates and the buckets are of drop forgings, being individually riveted to the wheel. The guide blades are similar in design to the revolving blades and are riveted to a segment fitted to the nozzle block. The governor is of the centrifugal type and is driven by means of worm gearing from the pinion shaft. An emergency governor, when required, is also mounted on this shaft. By driving the governor direct from the pinion instead of from the low-speed shaft, it would seem that a greater factor of safety is assured for the reason that, should anything happen to the teeth of either the main gear or the pinion, the governor is always under direct control of the turbine shaft itself.

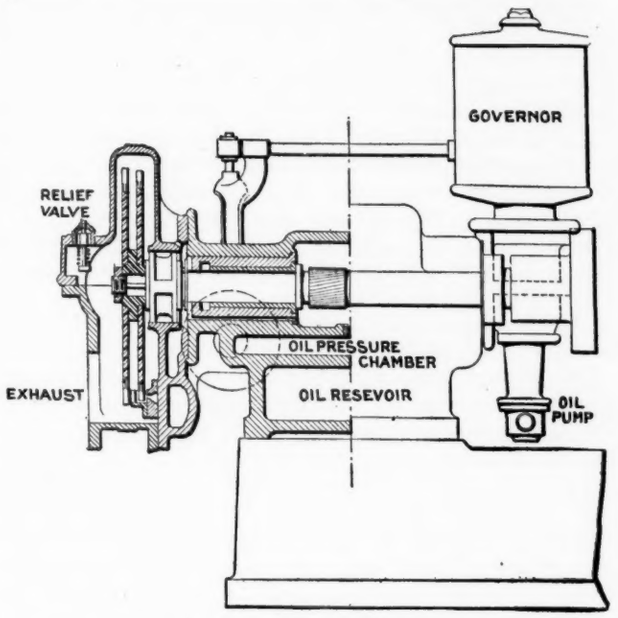


FIG. 1. SEMISECTIONAL VIEW THROUGH A STEAM MOTOR GEAR UNIT

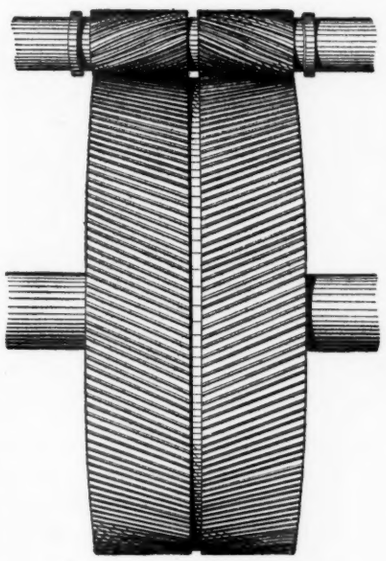


FIG. 2. PINION AND GEAR

The machine is fitted with a pop relief valve which is not of sufficient capacity to relieve the pressure in the casing resulting from the closing of the exhaust valve, but is intended merely as a signal valve in case of excessive back pressure in the motor casing.

A Sawmill Flywheel Explosion

The explosion of a flywheel in a sawmill, which caused the death of one man, the injury of two others and widespread property damage, is described in the January number of the *Travelers Standard*. The engine was of the Corliss type, running at a speed of about 92 r.p.m., the flywheel being 18 ft. in diameter with a face about 36 in. wide, belted to an electric generator supplying current for electrically driven wood-working machinery throughout the plant. The accident occurred soon after starting-up time in the morning, totally wrecking the engine room and throwing bricks and pieces of the broken flywheel in all directions. One of the spokes of the flywheel was thrown into the air, coming down through the roof of the sawmill about 150 ft. distant, striking a man who was working there and killing him instantly.

Appearances indicate that the bursting of this flywheel was due to overspeed, although the primary cause of the failure has not yet been ascertained. One of the commonest causes of flywheel explosions that occur in consequence of overspeeding is the failure of the governing apparatus. In the case of a belt-driven governor the belt may break or slip or come off the pulley on which it runs, or the key or setscrew which secures this pulley to the shaft may work loose or drop out. If any of these things should happen, the governor would become inoperative and the engine would be likely to run away. A similar result might follow the disarrangement of the mechanism of a shaft-driven governor or a governor of the centrifugal type. It is vitally important, therefore, to inspect the entire governing mechanism frequently and thoroughly and to make sure that it is in good working order at all times.

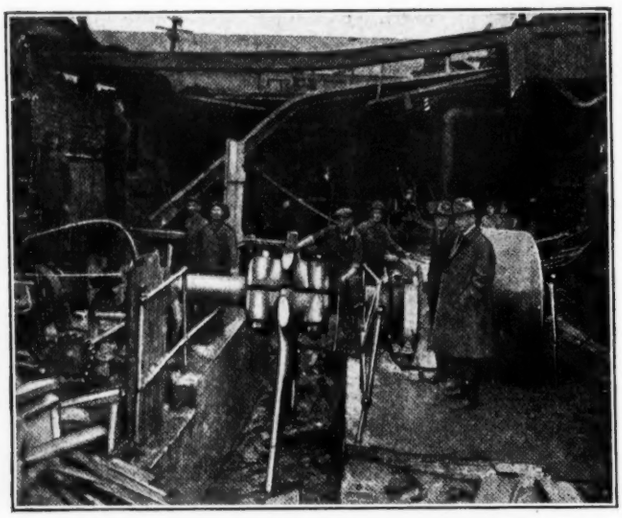


FIG. 1. THE REMAINS OF THE FLYWHEEL

The belts of belt-driven governors should be kept at proper tension and free from oil and grease which would cause them to slip. The key or setcrew that secures the governor pulley to its shaft should be kept tight, and the gears of gear-driven governors should always be well lubricated and in good condition in every other respect. For greater security a governor safety stop should be provided in connection with each flyball governor. This may be operated electrically or mechanically and should be arranged so that when the governor rod is bent to a dangerously low position (in consequence, for example, of the breaking of the governor belt) a spring or some other equivalent device will be released, which will close the steam-admission valve and stop the engine. A safety device of another form consists of a pulley that rests on the governor belt under ordinary circumstances and is connected to a quick-closing valve in such a way that the steam will be shut off if the belt breaks and allow the idler to drop. Other possible causes of overspeeding in connection with accidents such as the one under discussion are the breaking of the main driving belt and the sudden removal of the load on the engine due to the failure of the electric generator that the engine is driving. In either case the prompt and effective action of the governing and controlling devices must be depended on to prevent disaster.

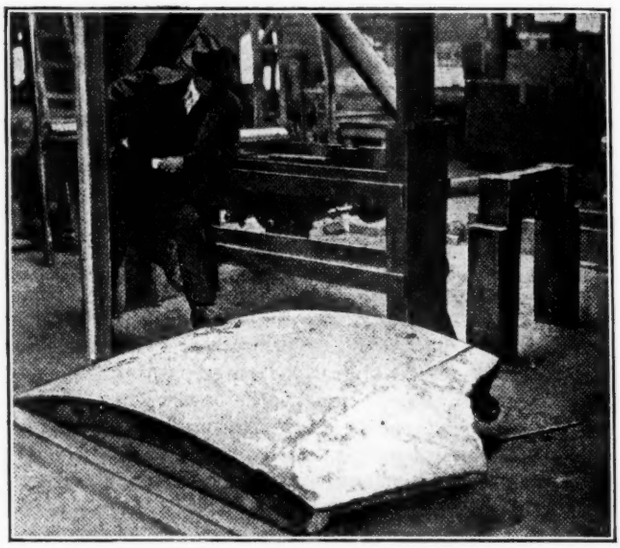


FIG. 2. A SECTION OF THE BROKEN FLYWHEEL RIM

There appears to be an unfortunate tendency on the part of many persons to place too much reliance on automatic safety devices and feel that the mere installation of them is sufficient to secure all the benefits and advantages that such apparatus is intended to provide. These persons are likely to become careless in performing certain duties that are absolutely essential for safety in the absence of automatic devices, and to either carry these duties out perfunctorily or omit them altogether. Even though material safeguards of the most approved type are replaced, personal vigilance should never be relaxed for a moment nor should any precaution ever be omitted to insure the safety of life or property.

Down in Memphis, Tenn., not long ago, a workman was trying to get the cap off a tank car full of gasoline. The cap stuck, so he took a hammer and chisel and "soaked" it. The result was a spark, the spark came in contact with gasoline vapor, and what followed cannot adequately be described. It is unkind to speak harshly of the dead, and this unfortunate has been sufficiently punished, but it is to be hoped that his fate and that of the nine others who went with him will serve as an object lesson of the pent-up viciousness that gasoline contains.

EDITORIALS

Why Wait a Whole Century for Results?

AT THE present rate of Federal administration of power applications pending before the Power Commission, there is one hundred years' business already at hand waiting action. It is high time Congress awoke to the fact that the present generation cannot wait indefinitely for decision of its power applications because of the failure to give to the Power Commission the very small additional sums that are needed to make effective the legislation that is already on the statute books.

Industry has accepted recent power legislation as adequate for the situation. This is clearly proved by the fact that over thirteen million horsepower is represented by approximately one hundred and sixty applications now pending before the Federal Power Commission. The Power Commission is sincerely striving to handle these projects promptly and effectively, but they are handicapped by a very limited force of barely thirty persons and these persons are simply loaned from other departments of the Government. Voluntary service for projects of this magnitude can never be an entire success. It is high time the commission had a staff of its own which will insure a continuity of thought, promptness of action and effectiveness in application of the power legislation that is already on the statute books.

American industry is seeking in every way possible to thaw out our frozen credits and resume normal business activities—construction, operation and otherwise. At the same time one goes to Washington and finds that Congress, by failing to grant the Power Commission a limited staff of its own, practically suspends operation on these tremendous power projects. Congress with great diligence labors upon legislation for the relief of the farmers, involving tens or hundreds of millions of expenditure or loans. At the same time the same honorable legislators sit back complacently and allow hundreds of millions of legitimate electric waterpower development to go by default simply for the want of a few hundreds of thousands of dollars on expenditures.

Those who believe in power development—and who does not?—can well ask why the bill introduced by Representative Esch (H.R. 15126) must so calmly repose in the hands of the select committee of water power of the House of Representatives. Why can we not get action on this bill? It involves no new expenditures of magnitude. It simply provides authority for the employment of personnel by the Power Commission, permits transfer of qualified members of other departments to the Power Commission without regard to petty detail of previous legislation and enables the Power Commission to do business in a businesslike way in its various relationships with other departments. Immediate action is imperative. We cannot, with any degree of mental comfort, wait for all these things until the present generation is dead.

The Standard Ton of Refrigeration

PROGRESS is made in small steps. After several years of discussion the "Standard Ton of Refrigeration" was defined at the annual meeting of the American Society of Refrigerating Engineers held in New York in December, 1920, on the recommendation of a committee of the American Association of Refrigerating Engineers working in conjunction with a similar committee of the American Society of Mechanical Engineers.

This standard ton is defined as the abstraction of heat at the rate of two hundred British thermal units per minute between the temperature planes of five degrees Fahrenheit and eigthy-six degrees Fahrenheit, corresponding respectively to nineteen and eight-tenths and one hundred and fifty-six pounds gage pressures for ammonia. The number of British thermal units per minute per ton (two hundred) has not been changed. This is based on the latent heat of melting ice as being one hundred and forty-four British thermal units, although the latest tests of the Bureau of Standards give the value as one hundred and forty-three and five-tenths. The difference is small and will not affect practical problems. Prior to this time manufacturers rated their machines at different temperatures, the majority using zero degrees Fahrenheit and ninety-five and nine-tenths degrees Fahrenheit. The new temperature planes will tend to increase the ratings of compressors. The rating will be increased, not only because of the increase in back pressure, but also because of the improved "volumetric efficiency" as a result of the decreased compression ratio.

It will be well for purchasers to remember that, in spite of any definitions of standard tons, the capacity of refrigerating machines under any given conditions of back pressure and head pressure will not increase. The ratings may go up, but the capacity depends on the actual conditions of operation.

M. B. S. for Patent Office Employees

EVERY few days an item appears in the daily press to the effect that Mr. Somebody-or-other has been awarded the D.S.M. or an equally important decoration, in recognition of his aid in carrying on the late world-wide struggle.

But up in the granite mausoleum at Eighth and G Streets there was, and is, a group of men whose work has been, is, and will continue to be of the utmost importance to the engineering and commercial welfare of the country at large—work that is carried on in the dull routine of every-day clock-punching service, amid surroundings of the most dispiriting and ambition-killing kind.

The work of the patent office examiner is never done and is rarely if ever appreciatively recognized except, it may be, on the part of some patent attorney, who thanks

his lucky stars that he is on the other side of the fence. The latest available report of the Patent Office, showing the "Condition at Close of Business, December 25, 1920," reveals that no less than 40,670 applications for patents were awaiting action at that time, the oldest new case bearing date of January 26, 1920, and the oldest amended case awaiting action bearing amended date of February 10, 1920. This means that some patent applications have not received a first action from the Patent Office in nearly a whole year. This regrettable condition of affairs is not the fault of the employees, but of the employers, the big patented-device using public, that as a rule knows little and cares less about Patent Office affairs.

The principal examiners, chiefs of divisions, are men who, notwithstanding their pay is small, especially considering the importance and responsible character of their work, have generally stood by their posts despite the increased cost of living, because they have felt their charges to be a matter of public trust, to which they have been faithful, in most instances, for many years.

Upon them and their working staff we propose granting the M.B.S., a decoration which, although devoid of ribbons and bars and stars, we believe would be fully appreciated and held at its full value.

The "Much Better Salaries" provision is in part covered by H.R. Bill 11,984, known as the Nolan bill, now pending before Congress, which provides for an increase in the number of Patent Office examiners and some increase in their pay. It is in a way only a makeshift and falls far short of adequate action for putting the Patent Office on a financial basis commensurate with the value of the work it performs, but it is a big step in the right direction and should have the hearty support of the engineering fraternity.

Prospects for Coal Legislation

LEGISLATION looking to the control of the coal industry is being taken seriously for the first time. This has been brought about largely by the testimony taken by the Senate Committee on Manufactures, in its hearing on the Calder bill, which provides for a far-reaching type of control of coal production and handling. The possibilities of success for some such legislation has been enhanced by the passage by the Senate, with plenty of votes to spare, of the bill providing for Federal control of the packing industry.

While an effort will be made to pass the Calder bill at this session of Congress, there is little chance that the measure will get through in the limited time remaining of the session. In all probability, the bill will be reported favorably by the committee. There is much opposition in Congress to licensing and price-fixing. Consideration of the bill would lead to very extended debate in the Senate, which probably would preclude its being pressed for a vote. The legislative progress of the measure, however, will be in its favor at the extra sesion. Considerable surprise has been occasioned by the amount of support which the bill is receiving. It is recognized that the bill must be altered considerably from its present form which contains several loopholes, notably in prescribing the limits for those operators and brokers that will come within the scope of licensing and the resale taxes. It is probable, however, that a number of changes will be made by the committee before it is reported out.

The Last Ship

WHEN at twelve o'clock, Saturday, January 11, the United States Army Transport "Aisne" left Hog Island for its trial trip, the stage was set for the opening of the last act of one of the most inspiring and most romantic chapters in American industry. The act closes with the formal transfer of the shipyards at Hog Island by the American International Shipbuilding Corporation to the United States Shipping Board Emergency Fleet Corporation on February first.

The first acts of this truly American drama were laid in the early days of our entry into the war. We needed ships. The race between U-boat sinkings and allied construction was in favor of U-boats. The American answer to this was the American answer to many a war problem—organization and mass production. Precedent after precedent was shattered at the Hog Island Shipyard. The job of building ships was undertaken by a company that had never built ships. Previous ideas of ship design and construction were overturned, and the idea of assembling ships on the job was projected. Instead of building one vessel to order at one time, a system of unit production was developed, and ships were assembled from parts made in various plants.

The first keel was laid February 12, 1918, and the first ship, "Quistconck," launched August 5, 1918. One hundred and twenty-two vessels have been built since that time. The great plant stretches two and one-quarter miles along the water front today with fifty shipways and all the building and machinery, railways, sewers, water works and electrical equipment necessary for the carrying on of this huge plant. Except for a few guards and workmen, it is empty. The final disposition of the yard is still problematical. But no matter what becomes of it, the spirit that drove the job through was the spirit that finished the war. It stands as a monument to American enterprise and industry, and to the men, many of whom put fifteen or twenty years of working life into three or four years in actual time.

Hoover Is Right

TAKE a look at the chart that appears on another page showing "Bituminous Coal Production for 1920." Then refer back to the chart on page 961 of *Power* for December 14, 1920, showing the "Production of Electric Power in the United States." Make a comparison; look at the graphs of coal production and those of electrical production. The former look like the shortest way home before prohibition; the latter, after prohibition. Then recall Herbert Hoover's characterization of the coal business as the worst-functioning industry in the country. "Sherman was right" is out of date; now it's "Hoover is right."

The editor was almost moved to tears at sight of a perspiring salesman at the Automobile Show explaining to a wealthy old lady the sequence of events in the operation of a four-stroke-cycle internal-combustion engine. "It seems awfully wasteful," she interrupted petulantly; "each cylinder is working only one-quarter of the time." And as the editor walked away, musing, he could have been heard to mutter, "She's not far off, at that."

Have you a *very old* engine, or pump, or other power-plant unit which is still doing good service? If so, send along a description and photograph on glossy paper, and *Power* will tell its readers about it.

CORRESPONDENCE

How Fast Does a Coal-Pile Fire Spread?

I have been much interested in the recent accounts of fires in stored coal as published in *Power*, and I ask if any reader can give data regarding the probable rapidity at which a fire will spread, say, in a pile of small coal up to one inch in size and in a pile of mixed lump and small coal, the height of the coal pile in each case being twelve feet.

Huddersfield, England. W. M. HEBBLETHWAITE.

A Depreciated Steam Plant

The superintendent of a small plant wanted to know what steps should be taken to conserve fuel in the boiler furnaces. This plant consists of two 125-hp. horizontal return-tubular boilers operating with hand-fired furnaces. At the time I visited the plant they were burning eight tons of coal in twenty-four hours to make steam for one 125-hp. engine and one boiling vat, having 135 lin.ft. of 1¼-in. pipe, and it was difficult for the firemen to keep up steam for the two units.

The boiler settings were in a depreciated condition, due to cracks and holes where bricks had been taken out to put in piping and had not been replaced. The draft at the furnaces was 0.04 in., and at the uptake or breeching 0.2 in. of water. The highest sample of CO_2 out of fifty was 8 per cent, with an average of 5.1 per cent. There was an opening of about one inch around the shell of the boiler in the breeching, and the leakage of air around the ironwork and where the piping entered the settings would extinguish a candle when held an inch away.

The tubes are blown once in twenty-four hours with a steam lance. I shoved a scraper into one of these tubes, but could not get it more than two-thirds through. The soot and ash were piled up to within three or four inches of the bottom of the shell back of the bridge wall, and the rear of the combustion chamber was filled to within about six inches of the back head of the boiler. The chimney is 80 ft. high and 30 in. in diameter. It was put up about two years ago and the operating engineer figured that it would take care of the two boilers. It has a brick base 10 ft. high, with a cleaning door 2 ft. from the bottom. This door has been covered with coal for the past nine months, which has made it impossible to clean out the chimney base.

The boilers had not been washed in five months, although they are down from Saturday noon until Monday morning of each week. The boiler-feed pumps are of the duplex type, the valve motion and rods are very badly worn and steam and water leak around the studs and packing. The feed water is heated in a 100-hp. closed heater. At times the water supply from the boiling vat is not enough for the boiler feed, and the fireman turns a valve on the city supply and feeds into the suction of the feed pump. This reduces the feed-water temperature from 150 to 70 deg. F. The feed-water supply is controlled by the throttle valve on the pumps. Most of the hot-water and steam lines are bare, and the steam traps blow directly through to the sewer instead of returning the water to a receiving tank.

The operating engineer had persuaded the management to purchase a turbo-vane fan to install under the furnaces so as to obtain a better draft. The superintendent wanted to know if the fan would reduce the fuel consumption. I informed him what he could expect if the fan was installed under the conditions that existed. The operating engineer installed the fan according to his ideas; that is, he placed it at the front end of one of the ashpits through the side wall, one half of the outlet being above and the other half below the grate. The steam line was connected to a line supplying the two boiler-feed pumps and a vacuum pump. The fan is run continuously whether the damper is open or closed, at about half speed by having the throttle valve cracked. There is no more draft in the furnace than there was before the fan was installed.

The superintendent wanted to know what benefit had been derived by putting in the fan. I told him he had added another ton of coal to his present waste. He tried to tell the engineer where he was wrong, in installing the fan the way he did. The engineer explained how he could prevent the air from blowing over the grates by putting a piece of tin over the outlet of the fan so placed as to form a baffle to direct the air downward in the ashpit.

While explaining the proper method of installing a turbo-vane fan for forced draft under return-tubular boilers, the engineer became very indignant and told me that he had installed a fan under a boiler in another plant in the same way. He explained that in this case he ran the boilers for three months without a chimney, as it had blown down and the plant was located where they could not get a chimney in a shorter time, but they got the fan and the fires were better than when they had a chimney.

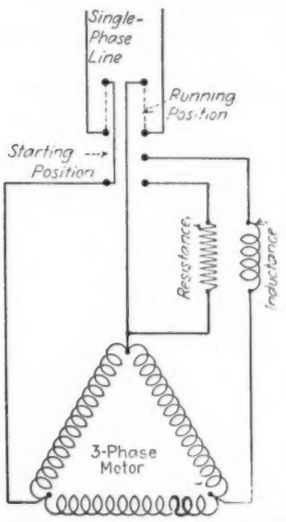
Whether the superintendent was afraid that no one else could operate his plant or that his engineer is right, I don't know, but the waste is still going on and the company is paying a man who classes himself as an engineer to operate its power plant in a most wasteful manner. C. J. MILLER.

North Tonawanda, N. Y.

Operating Three-Phase Motors on a Single-Phase Circuit

I have have found the article, "Operating Three-Phase Motors on Single-Phase Circuit," by Henry H. Brunner, in the Oct. 26, 1920, issue of *Power* very interesting since it brings to mind a scheme made use of by myself for starting polyphase motors in a repair shop where only single-phase power was available.

Mr. Brunner started the motor on three-phase and operated it single-phase. By using the scheme of connections in the figure, a three-phase motor may be started without load on a single-phase circuit. The resistance was made from a 25-hp. 220-volt direct-current motor starting box and was found to be good for starting three-phase motors up to 7½ hp. The two secondary coils of a 5-kw. transformer were connected in parallel and used as the inductance. Then by making up a special double-pole double-throw switch with an extra clip, the resistance and inductance could be cut in parallel for starting and disconnected from the circuit after the motor had come up to speed and the switch thrown to the running position. With a phase-splitting scheme of this kind the starting torque of the motor will be low and the motor will not come up to full speed until the switch is thrown to the running side. A. VAYDA.



STARTING THREE-PHASE MOTOR ON SINGLE-PHASE CIRCUIT

New York City.

Fuel Oil Ignited in the Economizer

A certain plant contained three Stirling boilers, with a 0.2-in. draft and burning crude oil, using four burners under each boiler. The load had been very heavy for some hours and the fireman was not an expert on oil burning. So when the demand came for more steam, he simply fed more oil to the fires and did not notice that they were smoking and not burning the oil completely.

A good deal of unburnt oil was carried off with the gases and lodged in the economizer, where it finally caught fire and made a fierce heat, practically making a boiler of the economizer. As the economizer relief valves were set three pounds higher than the safety valves on the boiler, the steam was forced through the feed lines into the boilers, and the water meter showed an evaporation of 70,000 lb., although the boilers could not evaporate that quantity of water, 35,000 to 40,000 lb. per hour being the general load.

The trouble was that the water meter was registering steam instead of water. The way to tell is by opening the small valve in the rear of the meter, which opens to the atmosphere. The feed pumps were running at the time and we let them run, and as the boilers were blowing we put out the fires by shutting off the oil supply. The trouble was soon over, because the fire burned itself out in the economizer chamber. As there were two 500-kw. turbines running at the time, it was not over an hour before the burners were all lighted and the boilers steaming as if nothing had happened. I do not suppose there is in this anything new to engineers or old fireman, but it may be of some good to young engineers and firemen who have not had such things happen.

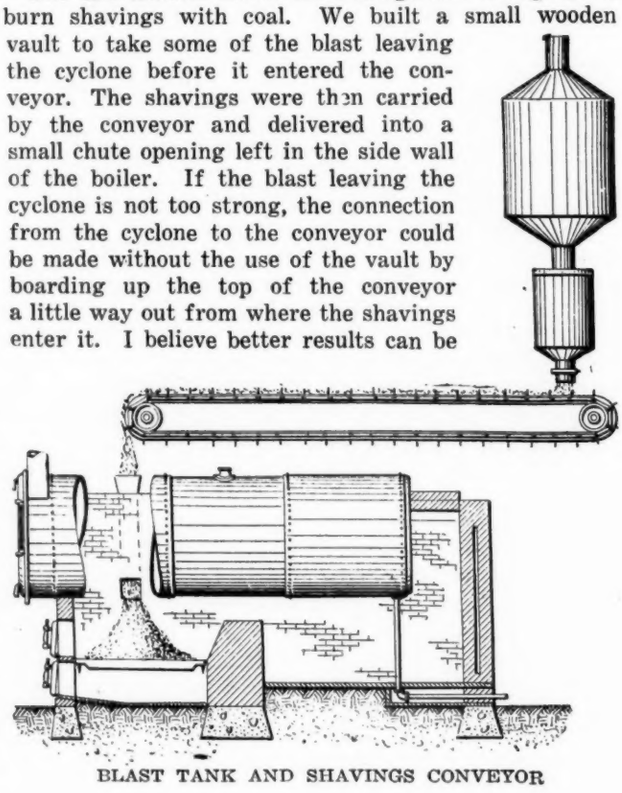
If the engines are running, do not shut them down; let them run. Do not stop the feed pumps and do not close the stack dampers, as this is likely to cause an explosion which will destroy the economizer walls and do other damage, such as breaking steam pipe and endangering life with flying brick. There is nothing that can be done to put the fire out in the economizer, at least not in the one I am speaking of; and as they are all on the same line of engineering, there will be but little difference in any of them.

Watch the water in the boilers closely. When you put out the burners, the water may drop out of sight in the glass in water-tube boilers. Do not get excited; keep cool, and know why you do anything and what the consequences will be before you do it, not after, as it will then be too late. FRED E. CUPPER.

Jacksonville, Fla.

Burning Shavings with Coal

The illustration shows an arrangement designed to burn shavings with coal. We built a small wooden vault to take some of the blast leaving the cyclone before it entered the conveyor. The shavings were then carried by the conveyor and delivered into a small chute opening left in the side wall of the boiler. If the blast leaving the cyclone is not too strong, the connection from the cyclone to the conveyor could be made without the use of the vault by boarding up the top of the conveyor a little way out from where the shavings enter it. I believe better results can be obtained from feeding shavings in this way, as it keeps the fuel burning more steadily and obviates the necessity of opening the firedoors and shoveling the shavings in by hand, thus letting in more cold air which, as is well known, is injurious to the furnace brickwork and to the boiler as well. G. L. BALDWIN.



BLAST TANK AND SHAVINGS CONVEYOR

Milkite, Vt.

Reducing-Valve Troubles

After using reducing valves varying from ½ to 8 in. in size, I have concluded that the single-seat valve remains tight longer than other types. The safety in installations requiring reducing valves lies in a relief valve placed next to the reducing valve and of sufficient size to hold the pressure from accumulating above the allowable limit should the diaphragm rupture.

In the regulator-operated valve the most trouble I find is the compensating device for controlling the pilot valve. Practically all hydraulic regulators when subjected to sudden changes, such as may occur in a reduced pressure line, have a tendeny to "hunt." If the same regulator were applied to the damper control of a boiler or to a battery of boilers the change in pressure would be so gradual that the instrument would work properly, but on a line carrying 5 or 10 lb. pressure the action might be far from satisfactory.

When a regulator acts as a damper control it is permissible to check the steam pressure by a throttling valve or cock, and on a reducing-valve regulator this method often makes the action very tardy. A well-built, well-designed oil gagpot on the diaphragm lever generally results satisfactorily.

It is best to use a small reducing valve when conditions will allow. For instance, a 2-in. pipe line might require but a 1-in. reducing valve. A 2-in. valve might possibly open so little that it would score badly and become leaky. A small valve could not leak as badly as a larger one, and on very light loads a large valve would supply too much steam when supposedly closed.

I have substituted a 2-in. for a 3-in. valve and obtained satisfactory results. C. W. PETERS.

New York City.

Superpower-Station Steam Pressure

In these days when the superstation is being discussed by a majority of leading engineers of this country and thought about more or less by everybody, it might be well to describe a few graphic reasons why we predetermine the working pressure in our superstation heat balance at 325 lb. gage and 200 deg. superheat, as delineated in the article in *Power* of June 1, 1920.

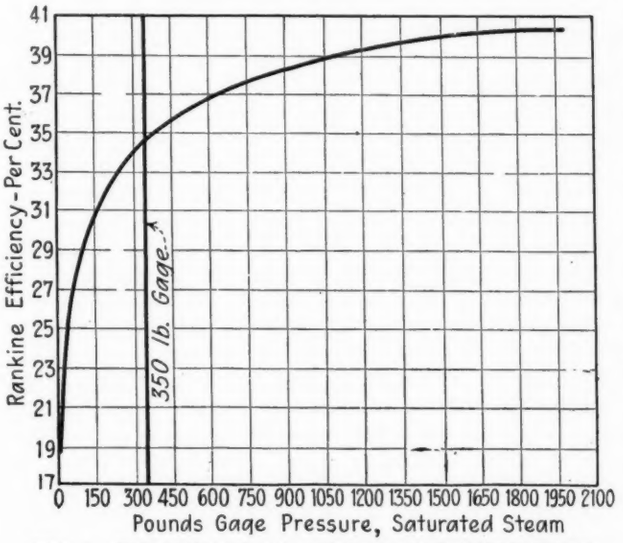


FIG. 1. EFFICIENCY OF THE RANKINE CYCLE WITH SATURATED STEAM

We intended the pressure at which the safety valve is set to blow to be 350 lb. and the superheat 250 deg. F. so that in no case would we get less than 325 lb. and at least 200 deg. superheat on the nozzles of the turbine;

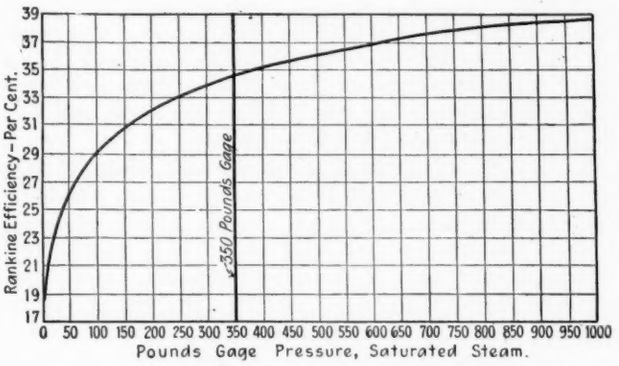


FIG. 2. EFFICIENCY OF THE RANKINE CYCLE

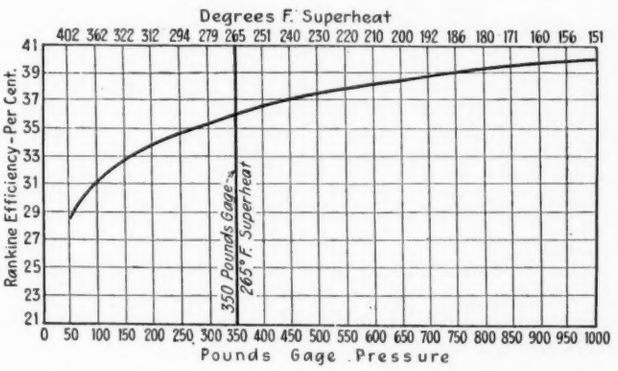


FIG. 3. EFFICIENCY OF THE RANKINE CYCLE WITH CONSTANT SUPERHEATED STEAM TEMPERATURE

and with 29 in. vacuum, power factor 0.8, an efficiency ratio referred to the Rankine cycle of 76 per cent is obtained. This was developed by the curves.

In our judgment, with the present stage of the art of metallurgy a maximum temperature of, say, 700 deg. F. should not be exceeded. Fig. 1 shows the variation of the efficiency of the Rankine cycle with working pressures from 0 to 2,000 lb., beyond which point the efficiency falls away, although the data are not well enough known to plot with precision. These pressures, of course, at the present stage of the art being out of the question, we stopped at a safe intermediate point on the high slope of the curve, approximately 350 lb.

Fig. 2 gives the efficiency of the Rankine cycle with various initial pressures of dry saturated steam. There is a gain of about 4 per cent from 150 to 350 lb. pressure and a gain of another 4 per cent, 350 to 1,000 lb. pressure, which in our judgment is too small a gain for the additional complication on boilers, steam pipes, etc., for the very high pressure.

Fig. 3 illustrates the efficiency of the Rankine cycle with various initial pressures at a constant initial temperature of 700 deg. F. and therefore shows our thought and action in using the special point of pressure on the steam curve, which would show the greatest efficiency at a medium high pressure. We wish to be recorded at the present time that we do not recommend any station carrying a working pressure of over 350 lb. gage. Beyond 1,000 lb. all curves are more or less hypothetical.

Copious criticism of this article is desired by the writer. JOHN A. STEVENS.

Lowell, Mass.

Is Massachusetts Going To Lie Down

Massachusetts has a model license law for engineers and firemen. In 1895 there was put upon the statute book a law requiring those operating and in charge of steam boilers and engines to obtain proper credentials. It was not a perfect law. It did form a very good beginning. At various times since then amendments have been made, and although the law still falls short of being perfect it is aimed in the right direction.

At various times attempts have been made to kill the law—not openly, but under the pretense of making an improvement. At such times the stationary engineers and firemen, assisted by a few public-spirited citizens, have fought the issue with success. The hardest fight of all came last winter. The State Senate actually passed an amendment of the hostile sort; but happily reconsidered its action the next day and killed the measure. The attempt is to be renewed this year, and by the same forces; and it behooves those who care for public safety in the Bay State to get ready for a struggle.

The present law requires that the person in charge of a power plant have a suitable license, also that at least half of the operators in the engine room and half of those in the boiler room be duly licensed. The grade of license required depends upon the size of the plant and the degree of responsibility. The proposed amendment provided that only one man—the one in charge of the plant—should be required to hold a license. As the man in charge need not be in the plant over an hour a day this meant that any large plant might be operated almost all the time by unlicensed men without any competent supervision.

The men who appeared before the legislature were mill managers and master mechanics from a certain city. In that city there had been a strike of firemen and engineers. The strike is mentioned because it came out that the sole purpose of the amendment was that future strikes might be broken. The mill representatives felt that the present law gave the engineers the upper hand. They wanted the law changed so that they themselves might have the upper hand.

This raises a very pertinent question. What are license laws for, anyhow? To increase wages? If so, license laws should not be amended; they should be abolished. Not only would a law with such a purpose be very unjust, but experience has proved that it has never brought about any such result. First-class engineers have been working for less wages than were accorded to second-rate weavers. Chief engineers of big plants in Massachusetts have been getting far less than men who were driving bakers' carts. The men in power plants have worked longer hours, under severe conditions, and have been getting far less than other men in the same mill who work under far easier conditions. Many licensed men have left the state and secured positions in states where no license was required, at a substantial increase in salary. If the purpose of the license law was the raising of wages, then the engineers themselves ought to go up to the State House and demand its repeal. Yet there seem to be a great many employers and a few engineers who are afflicted with this delusion.

The men who put the license law upon the statute books and those who have kept it there labor under no such delusion. They recognize no connection between salaries and license laws. To them the law means safety, and that alone. Their purpose in securing and preserving the law is the protection of the public (including themselves) from boiler, flywheel and turbine explosions and other kindred accidents. On page 3 of "Steam Boiler Explosions," published by the Fidelity and Casualty Company of New York, we find this: "Every year there occur in the United States between 1,300 and 1,400 serious boiler accidents, of which 300 to 400 are violent explosions. These accidents kill between 400 and 500 persons, injure 700 to 800 more and destroy more than half a million dollars' worth of property." The purpose of license laws is the saving of those 400 to 500 lives every year, the prevention of burns and other injuries to 700 to 800 more.

There are some who argue that it would serve as well, that as safe condition would obtain, if only the man in charge of the plant (or possibly the man in charge of each watch) was licensed. Now if the safety of a power plant depended upon design alone this argument would hold, but such an assumption has not a leg to stand on. If safety were a matter of obedience of certain rules, then again the licensing of the men in charge might be sufficient. But who is going to make rules to cover all sorts of power-plant emergencies?

When the law was enacted pressures of 80 lb. per sq.in. were considered high; the extreme limit of rim speed of flywheels was a mile a minute. Now we find pressures of 200 to 300 lb. per sq.in., and turbine wheels running up to 900 miles per hour. If any change is to be made in the license law it would seem that it should be in the direction of making it tighter instead of looser. Power plants contain machinery that is vastly more intricate and that therefore requires more intelligent supervision than anything that was to be found in 1895. Then a boiler of 500 hp. was large; now we have them of 3,000 hp. Then a prime mover of 5,000 hp. was considered large; now they are many times as large.

When manufacturers say, "We have got to have production, we will take a chance with boiler explosions, flywheel wrecks and other catastrophies if you will let us run the mills," they are taking the wrong tack. If they wish to steer toward greater production they should come about and head on a very different course.

The stationary engineers of Massachusetts have honored their state by putting upon its statute book a law that has served everywhere as a model. They intend that the state shall continue to enjoy that honor. If need be they will defend that honor. And those who would attack the license law had better understand that the engineers have been fortified by recent changes in the constitution. We can demand a referendum in Massachusetts. The engineers can put any changes that the legislature may make before the people, and if occasion arises they will gladly do so. The law is in the interest of the whole people, and there is a big body of engineers in the state who will see to it that the people understand the matter in its true light. When the voters of the commonwealth are shown that the license law is for their good, that greater safety is really secured as a result of the law, that the license law does not result in higher wages and that the engineers are not interested in that, anyway, but that their interest in the matter is mainly that they are the ones that are likely to be nearest to an explosion, and that their interest is more acute because they, better than any others, realize the danger, then there will be no doubt as to the result of a referendum.

West Somerville, Mass. WILLIAM E. DIXON.

INQUIRIES OF GENERAL INTEREST

Sulphur in Fuel Oil for Internal-Combustion Engines — For oil engines is it advisable to use a fuel oil carrying considerable sulphur? We can purchase such an oil for about 25 per cent less than an oil of the same gravity but having only 0.5 per cent of sulphur. W. R. S.

With modern designs of engines, there is no reason why oil carrying as high as 3 per cent sulphur should not be used. The sulphur undoubtedly will unite with the water vapor formed during the combustion of the fuel if the temperature in the exhaust is below the saturation temperature. This can be avoided by carrying the exhaust line fairly warm.

Repair of Leaky Girth Seams Having Fire Cracks—We have two horizontal return tubular boilers that leak at the girth seams, caused by fire cracks. I have tried calking and replaced the old rivets with larger ones driven in reamed holes, but cannot stop the leaks. I want to prolong the life of the boilers. What is the remedy for the trouble? G. B.

If the fire cracks at the points of leakage extend clear through the outside laps, or the material has been so badly burned as to render the texture of the material unsuitable for calking after cutting away the burnt edges of the laps the remedy would be to replace the burnt portions of the shells with patches.

Load Current and Voltage from Generator Voltage—If a load is supplied from a generating station over a transmission line, is there any way other than the cut-and-dry method, of determining the voltage at the load and the current necessary to supply a certain number of kilowatts to that load, knowing the voltage at the generating station? S. W.

If the power supplied is direct current and the load is the only one supplied over that line, and if the resistance of the line is known, the current drawn for a certain load is given by the formula,

$$I = \frac{E - \sqrt{E^2 - 4W \times R}}{2R}$$

where I is the current required, E the voltage at the generating station, W the watts (1000 × kw.) consumed by the load, and R the resistance of the line in ohms. The load voltage is equal to $E - IR$.

Charging Storage Battery in Lamp Circuit — Can a storage-battery cell be charged from a lighting circuit by cutting one wire supplying several lamps and connecting the battery in series with those lamps? If so, what will be the effect on the lamps? W. B.

A battery may be connected in series with lamps for the purpose of charging it, provided care is taken to have correct polarity. Otherwise the battery will discharge and, if left long enough, may be seriously damaged. If the connection gives correct polarity for charging, the lamps will be slightly dimmed, as the voltage of the battery opposes that of the circuit and the voltage on the lamps will be the difference between the two. If the connection gives wrong polarity, the lamps will burn more brightly, as the voltage of the battery assists that of the line.

Range of Single-Eccentric Corliss Cutoff—With a single-eccentric Corliss engine, why cannot the range of cutoff be obtained through more than one-half stroke by giving the steam valves negative lap and setting the eccentric with negative advance the same as with a double-eccentric Corliss? R. G. N.

Cutoff at later than one-half stroke could be obtained, but setting the eccentric back of the 90-deg. position gives rise to impractical operation of the exhaust valves. An exhaust valve opens and closes for the same position of the wristplate. If the valve has no lap when the wristplate is in its central position, and the eccentric is set behind the 90 deg. position (that is has negative advance), the exhaust valve would not open until after the beginning of the stroke from the opposite end of the cylinder; and as 180 deg. rotation would be required to bring the valve back to the same position, it would not close until the piston had proceeded on the power stroke from that end of the cylinder which contains the valve. If the valve rod is adjusted so the valve has enough negative lap to open earlier, it will remain open all the longer for steam to blow through after the beginning of a stroke from the same end of the cylinder. On the other hand, if lap is given to the valve to prevent steam from blowing through, it will be opened still later in the piston stroke from the other end, and the greater delay of release will further increase the back pressure.

Water Discharged from Orifice Under Different Heads—If there are two openings of the same size in the side of a standpipe, one 6¼ ft. and the other 56¼ ft. below the surface of the water, what would be the relative rates of discharge from the orifices? C. V. J.

The theoretical velocity of discharge of water through an orifice is the same as the velocity acquired by fall of a body in vacuo, given by the formula, $v = \sqrt{2gh}$, in which v represents the velocity in feet per second, g the acceleration due to gravity, usually taken as 32.16, and h the height of the fall in feet, which, in considering the velocity of discharge through an aperture, usually is taken as the height in feet measured from the center of the aperture to the surface of the liquid. The actual velocity of discharge is given by the formula $V = c\sqrt{2gh}$, in which c is a constant less than unity, its value depending on the size, shape and form of the sides of the orifice and the influence which the sides of the standpipe or vessel that contains the liquid may exert on the velocity of approach to the orifice. If the orifices are small compared with the size of the standpipe and depth of water below the lower orifice, the coefficient will be substantially the same for orifices of identical size, shape and form of sides. Hence if D is the distance in feet from the top of each orifice to the center, and one orifice is 6.25 and the other 56.25 ft. below the surface, the relative velocities and rates of discharge would be as $c\sqrt{32.16\ (6.25 + D)}$ to $c\sqrt{32.16\ (56.25 + D)}$, or as $\sqrt{6.25 + D}$ to $\sqrt{56.25 + D}$.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Symposium on Hydro-Electric Development

SINCE the passage of the Federal Water-Power Act by Congress there has been much discussion on the increased interest in water-power development. This interest took concrete form when some 400 mechanical, electrical and civil engineers met in the auditorium of the Manufacturers Club, Philadelphia, Pa., Friday afternoon and evening, Jan. 21, and discussed the various phases of hydro-electric development. This meeting was held under the auspices of the Engineers Club of Philadelphia and the Philadelphia section of the American Society of Civil Engineers, American Institute of Electrical Engineers, and American Society of Mechanical Engineers. Six papers were presented in the form of a symposium on Hydro-Electric Development and Distribution.

At the opening of the afternoon session Guilliaems Aertsen, president of the Philadelphia Engineers Club, addressed the meeting and remarked that, the meeting representing as it did the three largest engineering organizations getting together for a common purpose, marked the leading up from the lower levels where petty jealousies and prejudices existed between engineers of different professions and organizations. These jealousies are gone, and in there place a healthy rivalry exists and a consciousness of co-operation for the best interests of all.

Discussion of Modern Hydraulic Turbines

Frank H. Rogers discussed the modern hydraulic turbine and pointed out that cost per turbine horsepower is usually reduced by installing large high-powered units. The greater uniformity of load, higher load factors and large power requirements have made the only limit on the size of hydraulic power units that of the railways. To meet the present immense power demands by large central stations interconnected electrically has resulted in five important requirements for hydro-electric stations: High-powered units, high speed, high efficiency, reliability and durability. These requirements create a demand for turbines of highly specialized design. Reliability is of great importance, since if the unit is down the power is lost without any saving. If a 30,000-hp. unit is shut down for one day, even when power is sold for $15 per horsepower-year it results in a loss in revenue of $1,200 for each day the unit is out of service. As an example of the reliability of the modern hydraulic turbine some of the 10,000 hp. units at Cedars, Que., Canada, have operated for 30 months continuously 24 hours a day without a shutdown. In many of the large units the turbine casing is cast into the concrete substructure of the plants; therefore if the casing were to fail it would mean practically rebuilding the unit, consequently reliability cannot be overemphasized.

On durability depends the performance of the turbine after it has been put in service. Turbines have been installed that showed high efficiencies when first put in operation, but have fallen down badly after running for short periods, owing to wear of the different parts. Where the amount of water that can be used for power purposes is limited, this falling off in efficiency results in a direct loss in revenue.

Special care must be given to the design of all parts of the hydraulic installations. Tests of runners alone at the Holyoke Flume are no longer sufficient; completely equipped laboratories have been built for testing the entire hydraulic layout. The relative importance of certain features of design depends upon the specific speed. For low heads, high specific speeds must be used, resulting in high velocities at the runner discharge, so that draft-tube design is of great importance. For high heads, low specific speeds must be used, resulting in relatively large runner diameters. Water leakage at the runner seals and disk friction of the runner may result in serious losses unless special provisions are made in the design.

Norman R. Gibson told of the application of a new method of water measurement in the efficiency tests of the 37,500-hp. turbines of the Niagara Falls Power Co. On account of the restriction placed by law upon the diversion of water from the Niagara River for power purposes, the measurement of the quantity of water used in the various power plants at Niagara Falls is a matter of extreme importance. One per cent of the present allowable diversion of the American side is sufficient to develop 4,000 hp. in the existing plants. Revenue from this 1 per cent amounts to about $80,000 per year. Therefore, if the allowed capacity was reduced by 1 per cent the company would be deprived of $80,000 revenue, to which it is justly entitled, and since there is a shortage of power at the Falls, industries in this locality would be deprived of 4,000 hp. of much needed energy. These facts emphasize the importance of high efficiency and durability in hydraulic turbines where the use of water is restricted, or where the total water is used. From Mr. Gibson's figures it is evident that for each 1 per cent the efficiency of the turbines in the Niagara Falls Power Co.'s plants falls below the maximum the company loses $80,000 in revenue per year.

Measuring the Efficiency of the Turbine

The installation of three new hydro-electric units, each capable of generating about 37,500 hp., as described in *Power*, Sept. 14, 1919, made it necessary to determine by adequate means the efficiency of the turbines. To accomplish this Mr. Gibson has invented a means comprising a method and apparatus for measuring the flow of water in penstocks, which has been applied, and laboratory experiments have been made to determine the accuracy of the results obtained. In this method, known as the Gibson method or pressure-time process, the flow is measured by utilizing a record which is made of the changes of pressure that occur in the penstock when the turbine gates are gradually closed. The rise of pressure in the penstock when the gates are closed is recorded photographically, and the resulting diagram shows to exact scale a complete record of pressure changes and time, from which the volume of water flowing in the penstock may be calculated. From a series of 19 tests made at Cornell University comparing the results obtained by the Gibson method with volumetric measurements gave a mean variation of only 0.2 per cent. Some of these tests showed a plus variation, while in others the difference was minus, indicating that there is no inherent error in the device. A more detailed description of the Gibson method of water measurement in penstocks and its application will appear in an early issue of *Power*.

R. D. Johnson called attention to the conditions that could be set up in long hydraulic pipe lines supplying hydro-electric stations, when sudden changes of load occurred. He illustrated this point by comparing a long pipe line having a common type of surge tank on the discharge end and a forebay on the intake end, as a U-tube, the forebay being one leg of the U and the surge tank the other, the two connected by the pipe line. Under such conditions it is possible, where the load changes at frequent intervals on the plant, to set the water surging in the pipe line to an extent where the turbines would drop the load. If the friction loss in the pipe line is high, this surging will be minimized to a considerable degree, but can be properly taken care of by the use of a differential-type surge tank.

Differential Surge Tank

A properly designed differential surge tank will take care of the surge in the pipe line and leave to the turbine governor its proper function, that of varying the wheel-gate openings when actuated by a change of speed. The governor cannot function to any desirable degree at a speed regulator unless properly supported by several important features of hydraulic design, with respect to the general layout of the plant, such as capacity of the conduit, adequacy of the standpipe or surge tank, friction of the hydraulic system, inertia of the moving parts, characteristic power curves of the prime mover with respect to gate opening, etc. It is of great importance that there be a proper co-ordination of all the factors in order that the governor accomplishes its

intended purpose and to ascribe to it directly only such duty as it legitimately performs.

Mr. Johnson pointed out that the action of the governor is such as to keep the surge in motion when once set up, and if it were not for excessive loss of head the common type of surge tank would be practically useless. There are many opportunities for improvement in hydraulic-plant design. Considerable expense is gone into to get the last fraction of a per cent in turbine and generator efficiency when much larger losses are allowed to exist in other parts of the system due to hydraulic surges. The speaker suggests that waterwheel manufacturers rate their turbines at maximum efficiency and not the maximum horsepower that the wheels are capable of developing.

Trend of Turbine Development

"The Present Trend of Hydraulic Turbine Development" was the subject discussed by L. F. Moody. Early types of turbine were of the single-runner type and of comparatively small capacity. However, when a demand came for large units this was first met by using multiple-runner types, with as high as six wheels on one shaft. This resulted in a very complicated design, also a design that was not very satisfactory from the operation end, since many of the parts were so located that they were not readily accessible either for inspection or repair. However, with improvement in design it has become possible to meet almost any condition in a single-runner unit. An example of this is the 55,000-hp. units for the Hydro-Electric Power Commission of Ontario to operate under an effective head of 305 feet.

In the design of the turbine proper provisions must be made to take care of the discharge from the unit in the form of a correctly designed draft tube, or serious losses in efficiency would result. It was shown how the water as it leaves the runner is caused to whirl in the draft tube and how these whirls continue on down through the tube, causing considerable loss of head unless a correctly designed draft tube is used. A large percentage of the energy in these whirls is recovered by a new type of draft tube in use on 37,500-hp. units in Niagara Fall Power Co. new plant, and has resulted in the highest hydraulic-turbine average efficiency throughout the entire range of load so far obtained from a hydraulic turbine.

A new type of construction was suggested for low-head hydro-power plant. In this construction the water is caused to flow up through the turbine instead of downward as in the present vertical types. Provisions are made in the discharge construction to prevent the tail water from coming in over the turbine.

Considerable discussion was centered around a new type of high-speed runner which is a modified form of propeller. Experimental work carried out so far on this type of runner gives promise of favorable results as a hydraulic power unit.

Events of the Evening Session

At the evening session John L. Harper addressed the meeting on Niagara Falls Power Development. Both water power and coal represent energy from the sun. However, water power is the result of an ever repeating cycle. Of the water falling on our northern boundary a large percentage of it runs into the Great Lake basin. The Great Lakes system with the exception of Lake Ontario forms a vast storage reservoir, which overflows through at Niagara River at the reasonably uniform rate of about 210,000 cu.ft. per sec. Lake Ontario is a level below Lake Erie such as to make possible the utilizing of this vast volume of water at over a 300-ft. head, consequently each cubic foot outflow is capable of producing approximately 30 hp. This gives Niagara energy in excess of 6,000,000 horsepower.

Four general claims have been set up to the waters of the Niagara River: (1) That of navigation; (2) the maintenance of an impassable barrier to protect us from our Canadian brothers; (3) the preservation of scenic grandeur; (4) the utilitarian.

As to the merits and necessities of these claims, it may be said:

1. It is a perfectly practical and reasonable engineering feat, by means of remedial works, to maintain the levels of the navigable part of the Niagara River and all the Lakes which it drains, and at the same time make any desired diversion in the use of the water between, maintaining it in its natural channels and deflecting it into artificial channels for power development.

2. Little is necessary to be said on the maintenance of a protective boundary between our own country and Canada, as history and the existing feeling of the inhabitants of both countries indicate that we much prefer to fight side by side for the same humanitarian purposes rather than to fight one another.

3. It is gradually but definitely dawning upon those who have been most horrified at the idea of using Niagara's waters for other than present esthetic display, that vast quantities of this water flowing over the cataracts make extremely inadequate or no return at all in scenic value, but only noise; and that there may be proper remedial works so constructed that a very much smaller quantity of water may produce an equal amount of scenic effect and at the same time have the catastrophic recession of the Horseshoe Fall stopped for all time. Surveys show that the Horseshoe Fall has receded 950 ft. since 1764.

4. The utilitarian claim represents the demand not only of the people in the immediate vicinity, but those throughout our whole country who are shut out from the rapture that would be brought to their souls by a constant view of this scenic grandeur and insist that their part in the heritage which all of our people have in the Niagara be brought to them in their homes and their business. To supply these necessities for the safety, comfort, enjoyment and health of 99 per cent of the people of our country is the one and only reason for the development of Niagara's power. The conservation of too much scenery results in national waste.

David B. Rushmore outlined the problem of power production and the electrical features of hydro-electric power development. One of the real problems in water-power development is economic; namely, to find the sources of water power that it will pay to develop. The speaker emphasized the necessity of continuity of service, but this must be done without excessive expense.

Mr. Rushmore expressed the opinion that one of the important future sources of power would be plant life. Some forms of plants would be raised from which alcohol would be made for power purposes.

Educational lectures are being given under the auspices of the National Association of Stationary Engineers, Indiana No. 16, Anderson, Ind. A list of the subjects and speakers as announced is as follows: Feb. 3, "How to Build up Furnace Efficiency," by Joseph W. Hays, of the Jos. W. Hays Corporation; Feb. 17, "Results of Keeping Power-Plant Records," by Fredrick L. Ray, Union Traction Company of Indiana; March 3, "Conservation of the Coal Supply," by G. M. Alexander, of the Central Heating Co.; March 17, "The Value of Graphic Meters in Power-Plant Operation," by J. O. Pennisten, of the Union Traction Company of Indiana; March 31, "The Smokeless Combustion of Coal," by H. C. Carroll, combustion engineer; April 14, "Removing Soot from Boiler Tubes," Moving Pictures by Diamond Power Specialty Co.; April 28, "Metallic versus Fibrous Packing," by S. R. Bowen, of the Garlock Packing Company.

Contending that the Federal Power Commission has no jurisdiction over water power except in regard to obstructions to navigation, the attorney-general of New York State has filed objections to the applications made by twelve associations and corporations for permission to use the waters of the Niagara and St. Lawrence rivers for power. It is claimed that the state owns the river beds and should receive any revenue produced by utilization of this flowing water.

The Water-Power League of America, Inc., held its annual meeting in New York City recently, but very little was done in the way of final action. It was decided not to elect any officers at the meeting, and so a nominating committee was appointed to handle the matter. The league is of a political rather than technical nature and aims to influence water-power legislation.

Marine Engineers' Convention

The National Marine Engineers' Beneficial Association held its forty-sixth annual convention at Washington, D. C., during the week beginning Jan. 17, with headquarters at the New Ebbitt Hotel. There were present 74 delegates representing 38 subordinate associations, with a total vote of 245.

A large volume of business was transacted with harmony and dispatch. Several requests for permission to address the convention were refused for want of time, and only those presenting the most important measures were given the privilege of the floor. There were over forty interesting and essential resolutions brought before the delegates, showing a desire for the betterment of the organization. These resolutions were referred to the good of the order, finance and constitution committees. Financially, the organization is in a sound condition, and there has been an increase in membership of 2,400.

At the Monday morning session General George Uhler addressed the convention and his remarks were warmly received. On Monday afternoon Rear Admiral William S. Benson, Chairman of the United States Shipping Board, spoke to the delegates on the present condition of the Shipping Board. Commander R. D. Gatewood, of the Repairs and Construction Department, talked to the delegates on Monday evening, and was followed by Darragh DeLancey, Director of Division of Industrial Relations of the United States Shipping Board. On Tuesday afternoon Robert Fechner, of the Machinists Union, addressed the convention.

The officers of the organization, who were elected for three years, are: William S. Brown, president; John S. Purdie, first vice president; William H. Hyman, second vice president; Edward C. Killian, third vice president; George A. Grubb, secretary-treasurer.

The entertaining features of the convention consisted of theater parties and shopping trips for the ladies. On Wednesday afternoon a visit was enjoyed by the ladies to Mount Vernon by the courtesy of the France Packing Co.

The big feature was the smoker on Thursday night in the Hall des Nations of the Washington Hotel. This entertainment was tendered to the delegates by the Marine Engineers' Supply Men's Association. There were upward of 500 in attendance, including Army and Navy officers, heads of the various departments and engineers from the local associations. Brierwood pipes, tobacco, cigarettes and cigars were distributed, and an appreciated vaudeville performance was furnished.

The Marine Engineers' Supply Men's Association elected the following officers: President, Charles A. Remsey, Dearborn Chemical Co.; vice president, Allen Scott, Johns-Manville Inc.; secretary-treasurer, Bob Jones, France Packing Co. The retiring president, Andrew Lauterbach, was presented with a handsome traveling bag, the gift of the supply men.

Power Commission Badly Hampered

The Federal Power Commission's authority for employment of personnel is so limited as practically to preclude successful operation. The bill by Representative Esch (H.R. 15126) now pending before the select committee on water power of the House of Representatives, is intended to correct these conditions by amendment of the Federal Power Commission Act in the following particulars: (1) Authorizing employment of personnel in the District of Columbia and elsewhere; (2) permitting transfer to the Power Commission of employees of other Government departments without regard to the rule requiring three years' service before transfer, which now prevails; (3) authorizing the use of a portion of the appropriations for printing and binding, and purchase of books and periodicals; (4) providing for reimbursement of other departments of the Government from the appropriations of the Power Commission for work done by these departments on request of the commission.

Unless all these items are authorized successful operation of the commission during the fiscal year beginning next July will not be possible. One hundred and sixty applications, representing approximately 13 million horsepower, are pending before the commission. This is five times the horsepower of all the applications handled by all of the Government departments in the twenty years preceding the establishment of the Power Commission. This is good evidence that the Power Commission is accepted by industry, especially the electrical industry, as being properly provided for and adequate to its needs. Nevertheless, means for handling this tremendous mass of business are not available.

Cuts in the appropriation for the War and Agricultural Departments, from which the staff are now loaned to the Power Commission, will make it even more difficult next year to continue the present staff than it has been in the past. The need for employment of staff directly by the commission is, therefore, even more urgent than formerly.

Appropriations for the Power Commission were requested for the year beginning July, 1921, in an amount of $482,000. The Appropriations Committee of the House of Representatives recommended $100,000; this sum was approved by the House, and the Sundry Civil Appropriation Bill now pending before the Senate Committee on Appropriations carries this item. The prospects under present conditions are that this item would not be increased by the Senate, as it is felt that without authorization for employment of personnel the commission cannot even spend this smaller amount effectively.

Delay on the part of the commission delays beginning of many power operations. One company alone in California expects to spend $1,000,000 a month just as soon as the commission can act on its case. Another company in New York state is ready to start its steam shovels the

DELEGATES TO THE FORTY-SIXTH ANNUAL CONVENTION OF THE NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION

day approval of the commission is granted. At a time when everyone is anxious that no obstacle be placed in the way of resuming construction work and industrial activity it is very important that the Federal Government itself shall not by a petty policy of economy thus interfere with new business developments.

If the legislation does not pass before the end of the present session it is probably hopeless to undertake its passage at the opening of the special session, since Representative Esch and others who are particularly favorable to it will not be in the House of Representatives and the present special "select committee" will probably no longer exist in the next Congress.

Boiler Inspectors To Organize Nationally

An event that will be of the utmost importance to makers and users of steam boilers in all parts of the United States will take place when the National Board of Boiler and Pressure Vessel Inspectors holds its first really important and decisive meeting at the Statler Hotel, Detroit, Mich., on Feb. 2, 3 and 4. The board has already been organized on broad, general lines, but it is the purpose of this meeting to effect a permanent organization and put the undertaking definitely into action. The Jan. 11 issue of *Power* described at considerable length the big problem of co-ordinating the work of inspecting boilers in the different states and presented the proposed plan of organization of this board, and so all that is needed here is briefly to summarize the situation as it exists and the proposed solution, which is the National Board of Boiler and Pressure Vessel Inspectors.

As is quite generally known, a committee of the American Society of Mechanical Engineers has formulated what is known as the "A. S. M. E. Boiler Code," consisting of rules governing the design and construction of steam boilers that will be as safe to operate as possible. This committee, of course, has no authority over boiler users or makers, and so cannot enforce, but can only suggest, this Code which it has prepared. However, the self-evident need for a uniform, just, workable set of specifications that would hold good from California to New York has moved a number of local organizations voluntarily to accept the Code and to incorporate it in their boiler-inspection laws. Eleven states have done this, and thirteen cities and one county have taken similar action.

The result was not all that was desired because the Code is constantly subject to interpretation and revision, and local organizations of inspectors have remained at variance on details of its enforcement. To reduce the inconsistencies that have arisen in this way and to co-ordinate the efforts of the various boiler-inspection bodies that have a common purpose in reducing accidents, there was suggested a gathering together into one representative body of the heads of the boiler-inspection departments of each political district in which the A. S. M. E. Code was in effect. This was carried out in the organization of the National Board of Boiler and Pressure Vessel Inspectors in New York City on Dec. 2, 1919. The members of this board, however, have taken no collective action since that time, and so the coming meeting in Detroit is expected to mark the real beginning of the organization's work. The program follows.

Wednesday morning, Feb. 2, ten o'clock (Detroit City time): "Address of Welcome," by the Hon. James Couzens, Mayor of Detroit; "The American Society of Mechanical Engineers' Boiler Code," by Dr. D. S. Jacobus, acting chairman, A. S. M. E. Boiler Code Committee; "The American Uniform Boiler Law Society," by Charles E. Gorton, chairman; "Advantage of Interchange of Opinions of Boiler Boards," by C. W. Bissell, chairman, Michigan Board of Boiler Rules; "Qualifications and Duties of the Boiler Inspectors," by J. C. McCabe, Commissioner of the City of Detroit and Chief Inspector of Boilers for the State of Michigan; appointment of committees.

Wednesday afternoon, two o'clock (Detroit City time): "Necessity of Uniform Enforcement of the American Society of Mechanical Engineers' Boiler Code," by a boiler manufacturer; "Necessity for Co-operation Between Insurance Companies and State Boiler Inspection Departments," by S. F. Jeter, chief engineer, The Hartford Steam Boiler Inspection and Insurance Co.; "Uniform Rules for Low-Pressure Boilers," by F. W. Herendeen, secretary, the National Boiler and Radiator Manufacturers Association; "Duties and Possibilities of The National Board of Boiler Inspectors," by Fred R. Low, editor of *Power;* general discussion.

Thursday morning and afternoon, regular meeting of the Boiler Code Committee of The American Society of Mechanical Engineers.

Friday morning and afternoon, meeting for the purpose of completing a permanent organization.

Coal Operators Deny Profiteering

"It is clear, from the confidential reports of these producers, that loose and wide-spread charges of general, indiscriminate, conscienceless profiteering on the part of the bituminous coal mine operators are absolutely baseless and without justification." This sweeping statement has been sent out by John B. Pratt, Director of Publicity of the National Coal Association, and is based upon reports received from 494 operators in its membership, covering a tonnage of 100,446,304 produced by them from Jan. 1 to Oct. 1, 1920.

It is claimed, and apparently quite justly, that these figures prove that the bulk of bituminous coal, during the recent emergency, was sold at the mines at reasonable prices, which gave only a fair margin of profit. The average price is given as $3 47 per net ton at the mine, the average cost $2.76 per net ton and the average margin 71c. It is shown that 38.5 per cent of the total of 100,446,304 tons sold at an average price of $2.62 at the mine; that 39.7 per cent sold at $3.46; that 14 per cent sold at $4.36; that 4 per cent sold at $5.41; that 2 per cent sold at $6.44; and that the remainder, or a little more than 1 per cent, brought prices in excess of $7.

No figures are given out by Mr. Pratt as to prices paid by consumers, nor as to the source of the difference between such figures and the prices which he quotes. It is quite generally felt that publication of some such data as that would be even more interesting than the material that is presented here.

Massachusetts State License Law Under Consideration

A bill providing for the licensing of professional engineers in the State of Massachusetts has been drawn up by the Boston Chapter of the American Association of Engineers and introduced into the Legislature. An interesting feature of the proposed law would allow engineers from other states to practice in Massachusetts, provided those from Massachusetts are allowed to practice in the other states.

This bill and others like it should not be confused with existing and proposed legislation that concerns stationary engineers; the term "Engineers' License Laws" or a similar phrase is applied to both classes of laws and is likely to cause misunderstanding. The Massachusetts bill mentioned here is directed at professional men, and is chiefly of interest to civil engineers.

New York Boiler Inspectors Form Association

The Boiler Inspectors Association of the Capitol District was organized in the offices of the Travelers Insurance Co., at Albany, N. Y., on Jan. 15. Membership is restricted to boiler inspectors working under the New York State Boiler Code, and includes inspectors of the various insurance companies and of the State Industrial Commission. The purpose is to secure co-operation and exchange of views that will help the individual inspector in his interpretation and enforcement of the state boiler law.

The following officers have been elected: President, B. Plant, Travelers Indemnity Co.; vice president, W. Scott, Royal Indemnity Co.; secretary, F. Toener, Hartford Insurance Co.; treasurer, E. Hall, State Bureau of Boilers and Explosives.

Saponification, Emulsification and Adhesion Characteristics of Lubricating Oils

BOTH in studying the action of oil in the presence of water and that of an oil which will easily separate from water we meet the terms saponification, emulsion and adhesion. These terms have been used so loosely by some engineers and writers that apparently a confused impression seems to exist as to their real significance or, what is more important, as to the relationship which exists between them.

Saponification

Saponification is a chemical action pure and simple and should not be confused with any physical effects that may result therefrom. Certain organic compounds, on account of a great similarity in chemical properties and possessing certain particular physical characteristics, are grouped together and called oils. Based on origin, composition and chemical behavior, these in turn are subdivided into two general classes called mineral oils and fatty oils. One of the principal characteristics possessed generally by fatty oils and not by mineral oils is their susceptibility to a simple chemical reaction whereby the oils are split up and recombine with metals, generally those belonging to the alkali group. These combinations of the major portion of the oil molecule with a metal in this manner are called soaps and the chemical reaction is called saponification.

This property of fatty oils to easily produce soaps is used as a means of determining the presence of such an oil and approximately its amount in a mixture of mineral and fatty oils. Most fatty oils will react with caustic soda or potash to approximately the same degree; that is, equal amounts of fatty oils will neutralize the alkalinity of about the same amount of caustic. In order to be able to express this effect in figures, the number of milligrams of caustic potash that will react with or be neutralized by one gram of oil is called its saponification number. The saponification numbers of most fatty oils range between 190 and 200. By finding the saponification number of an unknown oil, a fair approximation can be made as to the amount of fatty oil it contains.

Emulsification of Oil

If a well-refined mineral oil and water are shaken up together in a bottle and then allowed to settle for a few seconds, both liquids separate with a sharp surface of demarcation and are clear. If, however, certain fatty oils or soaps are added to the mineral oil and the bottle shaken again, the two liquids will separate only very slowly or may even remain mixed practically indefinitely. This intimate mixture of oil or oil compound and water is called an emulsion. The term as used in the oil trade therefore may be defined as a very intimate mixture of two liquids that are insoluble or only slightly soluble in each other, which mixture is so stable and the liquids are so mutually held in suspension that separation due to differences in specific gravity or density is very slow.

The study of the causes of emulsification are still very incomplete, and there are many characteristics yet to be satisfactorily and completely explained according to the usually accepted theories of physical and chemical science, yet great advance has been made and sufficient experimental data have been accumulated to allow the prediction of results to a fair degree of accuracy. The most generally accepted theory is that there is a balancing of physical and perhaps chemical forces at the surfaces between the two compounds, in this case liquids, so that there is no resulting tendency for the separate drops to coalesce on the one hand or to further subdivide on the other. These forces are sufficient to prevent or at least so retard the action of gravity from separating liquids of different density that they remain in more or less permanent emulsion. Some liquids, as soluble oils, will emulsify spontaneously with great rapidity, the particles reaching their final balanced state of subdivision very quickly, while other liquids must be mechanically or otherwise atomized before they will remain permanently in suspension. In some emulsions the particles are so small that they can be observed under an ultra-microscope. When thus seen they are found to be in constant rapid motion, the smaller particles being most active. This is called Brownian movement. In some cases the particles are so fine that they cannot be seen by the ultramicroscope and are only believed to exist by reason of the fact that a beam of light is scattered in passing through a solution or liquid combination containing these particles. This scattering of a light beam, called *Tundal* effect, is generally taken as indicating the dividing line between a true, molecular, solution and an emulsion or colloidal solution.

The Property of Adhesion

As in the case of an emulsion of two liquids mutually insoluble or at most only slightly soluble there are certain interfacial forces operating at the dividing surfaces, so also between a solid and a liquid there are interfacial forces whose action depends on the composition and physical condition of the two substances. If mercury is brought in contact with glass under ordinary conditions, there is apparently no attraction between the two and the glass is not "wetted" by the mercury. There is, however, such an attraction between the two and it has been actually measured in units of force, but this attraction is less than that existing between the different mercury particles and none of the mercury adheres to the glass. If, however, mercury comes in contact with gold and some other metals, the attraction between the two metals is greater than the forces between the mercury particles and the gold is wetted by the mercury. This force drawing a liquid to a solid is called adhesion.

If oil comes in contact with glass the latter is wetted, showing that the forces between glass and oil are greater than those between the oil particles. Similarly, there is strong adhesion between water and glass. Now, if glass is wetted with an oil and then immersed in water, sometimes the water will replace the oil film on the glass and at other times the oil will not be dislodged, depending on the nature of oil or what may be dissolved in it or the water.

This same action is also true of steel. When wetted with certain oils it will entirely lose its oily coating when subjected to water, especially if warm, while other oils will not be displaced and the water will drain off, leaving the steel wet with oil.

No generally satisfactory method has been devised for measuring the adhesion between a liquid and solid, especially if it is stronger than the cohesion of the liquid, though where the forces of adhesion are weaker than those of cohesion, measurements have been made that are claimed to show the magnitude of adhesive forces. On account of this lack of actual experimental measurements the study of adhesive forces has been greatly retarded and their explanation has been more a matter of deductive reasoning from assumed hypotheses than is desirable for practical application.

Surface Tension Defined

In attempting to develop a reasonable explanation for adhesion and emulsion on the basis of the usually accepted physical and chemical conceptions, we meet another term; namely, surface tension. As mentioned in discussing emulsion at the boundary surface between two liquids not mutually soluble, or between liquid and gas, there apparently exists a different set of forces than are found in the interior of the liquid or gas. If a wire is immersed horizontally just below the surface of a liquid, which wets the wire, and then raised slowly, as the wire is drawn through the surface the liquid follows the wire just as if the surface were a membrane being stretched. The force necessary to pull the wire away from the surface can be measured on a balance, and knowing the length of the wire

this surface force of the so-called liquid membrane can be computed. This force, called surface tension, differs somewhat from that in a stretched membrane in that it is constant no matter how far the liquid is extended.

It is a fundamental scientific principle that any system possessing potential energy tends to change its form or condition so that this type of energy is decreased. As the energy in a liquid surface is a function of the surface tension and the area of the surface, and as the surface tension is constant, this potential energy will be decreased by a decrease in the surface area. Thus one liquid when surrounded by another liquid or gas, unless prevented by other forces, as those of gravitation, tends to form a sphere which geometrically has the least surface for the volume.

The phenomenon of surface tension, here briefly described, has been used quite generally and fairly successfully to explain emulsions, though it is apparent that other forces may be co-existent and must be considered, for the surface-tension theory does not completely explain all the phenomena. Whether there are surface tension forces in the solids or not, still there certainly are forces at the surface between the liquid and solid, as exemplified by adhesion and absorption, and we shall still stick to our term adhesion until a better one is established.—*Lubrication.*

Radial Brick Chimneys*

BY W. F. LEGGO

The first chimney of historical record was introduced in 300 B.C. and used by the Greeks in a crude form of smelter. In the ruins of Pompeii (75 A.D.) there was found a chimney in a bakery. Venice was one of the first cities to adopt chimneys, a number of them being overthrown by an earthquake in 1347. In the Fifteenth and Sixteenth centuries, we find many chimneys built of stone, some of them, notably in England, being very handsome architecturally and rich in carving, matching doorways and windows.

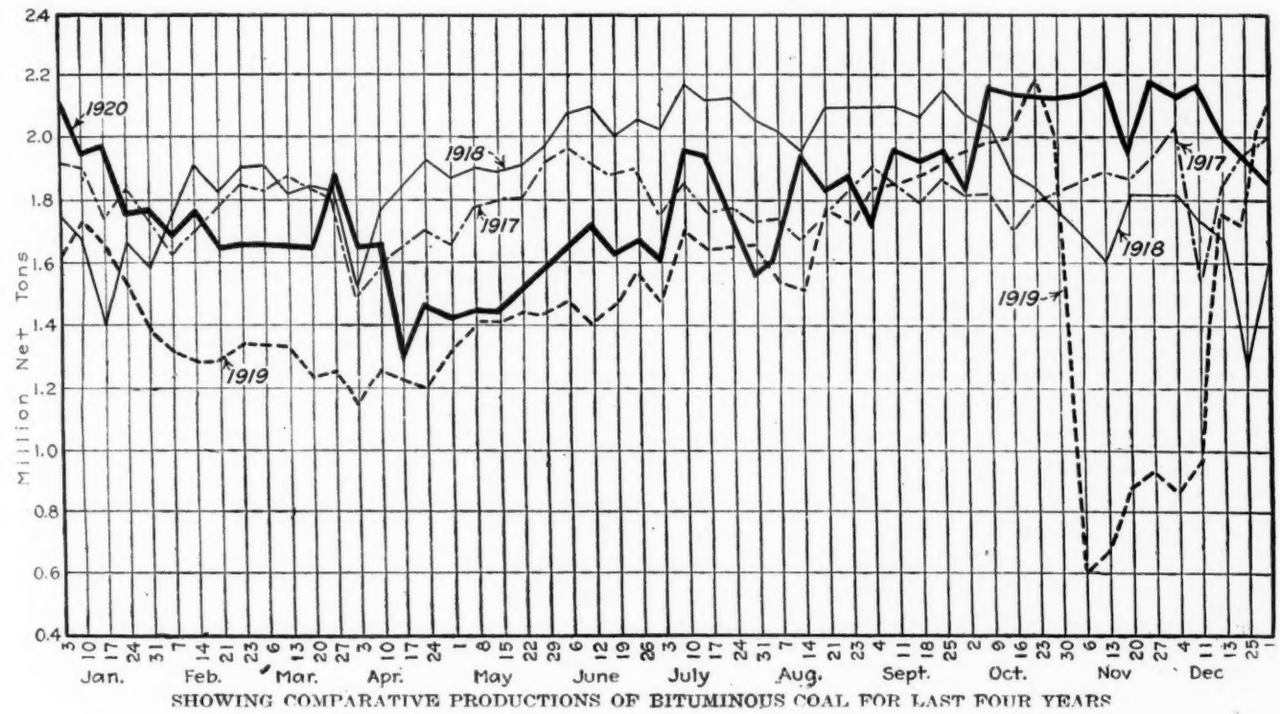
The commercial chimney came into use about the time of the power engine in 1706, and for over 150 years the only material used was brick of the old type (what we term common brick) or in some instances, stone. In the old type of brick chimneys the flue was usually rectangular and of the same dimensions from top to bottom, the wall being twelve inches thick at the top and increasing four inches (or the thickness of one brick) for every fifteen or twenty feet. Although expensive, this method was serviceable and many of these chimneys are still in use today. With the introduction of the radial brick chimneys, however, of today, we have circular flues, which offer much less resistance to the flow of the gases. The bricks are molded to fit a circle, and the standard face dimensions of chimney brick are 6½ in. wide and 4⅝ in high. The bricks are made in five standard lengths, ranging from approximately 4¼ in. up to 10¾ in. All the bricks are perforated, the holes being approximately 1 x 1½ in., ranging from four in the small brick to ten in the larger. The design of these perforations is figured on the basis of not having their area exceed 25 per cent of the cross area of the brick. The sides of the brick are corrugated in order to secure additional surface, the corrugations being about ¼ in. wide and ⅛ in. deep. In bonding so as to make up the several wall thicknesses, three courses of one size brick are laid on the outside and backed up with one or two smaller bricks on the inside.

In designing radial brick chimneys the standard practice is to allow compression in the brickwork up to 35,000 lb. per sq.ft. This is not excessive for the reason that all hard-burned chimney brick has a crushing strength of about 6,000 lb. per sq.in. Practically all the radial brick chimneys designed are of the tension type. The allowable tension should not exceed 5,000 lb. per sq.ft. in chimneys 150 ft. and higher, but in smaller chimneys it could run as high as 6,000 lb. per sq.ft. These limits are all figured on the basis of wind with velocity of 100 miles per hour, figuring the pressure on the brickwork at 25 lb. per sq.ft. on the projected area. Radial brick chimneys have been designed according to these lines for over thirty years without a failure. For ordinary boiler purposes where the average temperature does not exceed 600 to 800 deg., the lining in the chimney should be approximately one-fifth of the height.

*Abstract of article presented at the annual meeting of the American Society of Heating and Ventilating Engineers, January, 1921.

Bituminous Coal Production in 1920

The chart that is reproduced here shows the erratic variations in the daily production of bituminous coal, including coal coked, in the United States through the year 1920. It was prepared by the Geological Survey from its weekly reports, and is complete to the first of January, 1921. The Survey estimates that the total production of coal for 1920 was 556,516,000 net tons, as compared with 458,063,000 net tons in 1919, 579,386,000 net tons in 1918, and 551,790,000 net tons in 1917.



SHOWING COMPARATIVE PRODUCTIONS OF BITUMINOUS COAL FOR LAST FOUR YEARS

Washington News

Advocates Fixing Coal Prices—Hearing on Niagara Power

By Paul Wooton
Washington Correspondent

Something of a sensation was caused by the testimony of Dr. George Otis Smith, director of the United States Geological Survey before the Senate Committee on Manufactures in which he said that the coal trade should no longer be considered a private business. He declared that coal, in his opinion, is a proper subject for Federal control, as are the public utilities. Coming from a man of conservative tendencies and a recognized authority, not only on coal but on economics, much weight is being given his opinion. Coal, he declared, must be placed in the same category as are public utilities. He pointed out that there are emergencies in peace which are just as serious as are those caused by war. Since control was exercised to meet the war emergencies and were regarded generally as necessary measures, he can see no reason why provision should not be made in advance to meet possible emergencies in the future. He expressed surprise that there should be any opposition from a mine owner, a coal-land owner or a mine worker to the publication of certain essential facts which would give the consumer an opportunity to analyze the disposition made of each dollar he spends for coal. With regard to the regulation of prices, Dr. Smith sees in it a stabilizing element which long has been needed by the coal industry. He pointed out that it is in the interest of the consumer that the coal operator receives a fair return on his investment, "not simply for one year, but a fair return must be made for a series of years." He pointed out that the coal operators have a good many bad years over which to distribute their recent profits. He admitted that he has prejudices against price fixing, but as there is a condition to face some theories must be set aside. "If a government agency," he said, "supposedly impartial and supposedly fairly well informed, does not direct and influence the law of supply and demand, some more selfish interest will direct and influence it."

O. P. Hood, the chief mechanical engineer of the United States Bureau of Mines, appeared before the committee at its request to set forth the necessities of coal classification. He believes there is fully as much reason to control the quality of coal in time of emergency as there is to control it in any other way. Extracts from his remarks before the committee are as follows:

The Bureau of Mines has for some time past given consideration to the matter of coal classification. American coals are of such great variety and pass from one grade to another by such small differences in chemical, physical and other useful qualities that classification must use more or less arbitrary dividing lines. Preceding general coal classification there must be a method and mechanism for accurate and satisfactory sampling of coal as delivered in order to place the coal in the proper class. It is obvious that a sample must be thoroughly representative of the whole shipment of coal under consideration, else injustice and dissatisfaction will follow. This sampling and analysis of coal has been the subject of study and practice by the Bureau for more than ten years past and methods have been devised which have proved satisfactory to many purchasers and operators. It is believed that an application of these methods on a comprehensive national scale is possible.

Secretary Lane proposed two years ago a bill based upon this experience of the Bureau of Mines and upon the belief that while the expense of operation should be borne by the industry, the mechanism for inspection and analysis should be in the hands of the government, since it had become apparent during the war that such mechanism was sorely needed as a national protection in time of stress.

A method which the Bureau of Mines believes is practical is to establish coal-sampling stations at railway gateways or other convenient locations, where representative samples can be taken when desired of the coal as shipped. The analysis of this coal accurately determined and supplied to the operator will enable him to declare a standard for his coal which, because of the particular bed, mining methods, means for preparation and class of custom, he knows that he can maintain This standard being published by the Government gives accurate information to the buyer of what he can expect from that mine. The inspection service would discover whether shipments of coal were being maintained within the declared standard. This information would be given to the operator and the public, and the operator would be allowed to advertise that his mine produced coal whose quality was certified by the Government. If shipments became sub-standard, this privilege would be withdrawn and the operator required to declare a new standard which he could maintain or forego the advantage of Government certification of quality. The certification of quality by the Government is of value to the operator because of the confidence inspired in the purchaser and for protection from unjust charges concerning dirty coal which result from practices of other shippers. The certification of quality is of value to the purchaser in giving him reasonable assurance of uniform quality of coal. In all industrial operations involving coal, uniformity of quality is absolutely essential to reasonable efficiency in use. Devices are available to burn efficiently almost any quality of coal provided the quality varies within rather narrow limits, but no mechanisms have ever been devised that will maintain reasonable efficiency with fuels varying through a considerable range in quality. Variable coal quality inevitably means coal waste.

Hearing on Niagara Power

By ruling that it could not take under consideration applications for the prospective use of water under an amended treaty with Great Britain, the Federal Power Commission simplified the discussion at its hearing Jan. 24, 25 and 26, on the Niagara River projects. Several of the applicants had filed applications for preliminary permits involving the prospective use of water under an amended treaty. While the commission ruled against hearing these applications, it was made clear that this was not to preclude its consideration of possibilities under additional diversions in considering the proposals for the use of existing water.

An effort was made by the Niagara Falls Power Co., the Niagara Power and Development Co. and the Niagara, Lockport & Ontario Power Co. to reach an agreement that would prevent conflicts in their applications, but no particular progress was made in that connection prior to the ruling out of applications based on prospective diversions. The Niagara Falls Power Co. appeared in support of its application for the full 19,500 sec.-ft., the entire diversion now authorized, except for the 500 sec.-ft. that goes through the Erie Canal.

The Niagara Falls Power Co. proposed either to use the entire amount of the diversion at the Falls, or to use one-half of it at the existing plant at the Falls, taking the remainder over the top development. The opinion was expressed that the more feasible scheme would be to use the entire amount of the diversion at the Falls. That would require the construction of a pressure tunnel which would carry the additional 10,000 ft. down to the power house adjacent to the company's new plant. This would mean the eventual abandonment of the old plant above the Falls, although it would be kept in stand-by condition.

No one at present is contesting the claim of the Niagara Falls Power Co. except the City of Buffalo. In that connection it was brought to the attention of the commission that the City Commission of Buffalo is divided on the matter. It also was stated that it would require state legislation before Buffalo could undertake any such operation.

Development in the gorge is proposed by the Lower Niagara River Power and Water Supply Co. The company is affiliated with the Niagara, Lockport & Ontario Power Co. A gorge development also is proposed by the Niagara Gorge Power Co., which is owned by the Gorge Railroad Co. It was brought out that the gorge development must go before the International Joint Commission. The whole question revolves on the matter of retaining scenic features and on protection against ice jams.

Representatives of the State of New York appeared at the hearing and requested and received permission to file a brief subsequently. It was pointed out that the legislature just had convened and insufficient time had elapsed to secure legislation that would enable the state to act in water-power matters.

There were nine applications for water-power permits made to the Federal Power Commission during the week ended Jan. 22. This makes a total of 160 received.

Obituary

W. F. Warden, who has been president of the Burt Manufacturing Co. for practically thirty years, died on Jan. 20 of heart trouble, at Deland, Florida, where he was spending the winter.

Charles H. Armstrong, secretary-treasurer of the Armstrong Manufacturing Co., died recently after 35 years in the company's service. Mr. Armstrong was over 60 years of age, and his death was due to angina pectoris.

Joseph H. Roach, president of Joseph H. Roach & Co., automatic stoker manufacturers, died recently of a sudden heart attack at his Brookline, Pa., home. Mr. Roach was forty-seven years old, and is survived by a widow and four sons.

William H. Sayre, president of the American Abrasive Metals Co., died recently of a severe heart attack at his home in Glen Ridge, N. J. Mr. Sayre was a member of the American Society of Mechanical Engineers, and was also very active in the American Society of Safety Engineers. He organized the Federal and the Anthracite Electric Welding companys and was one of the first to apply electric welding commercially.

Personals

M. S. Hutton, of New York City, has been appointed secretary of the executive committee of the Professional Section on Fuels of the A. S. M. E.

Frank Conrad has been appointed assistant chief engineer of the Westinghouse Electric and Manufacturing Co., after almost thirty years in the company's service.

John Hunter, who during the war was naval constructor with the Standard Shipbuilding Corp. on Shooters Island, is now chief engineer of the Heine Safety Boiler Co., St. Louis, Mo.

Henry W. Blake, senior editor of the *Electric Railway Journal*, was recently tendered a dinner by his associates in the McGraw-Hill Co. in commemoration of his thirtieth year of service on the editorial staff of the *Journal*.

F. C. Reed, formerly manager of the price section of the industrial department, Westinghouse Electric and Manufacturing Co., has been placed in charge of the Bluefield and Charleston, W. Va., offices of that company, and is to be located in the Charleston office.

H. T. Pierce re-entered the employ of the New England Power Co., at Worcester, Mass., recently as a transmission engineer. He was with the New England Power Co. until a year ago, when he went to the West Indies and took up work with a sugar refining company in San Domingo.

James MacGuire, formerly chief inspector of power-plant equipment, Air Nitrates Corporation, Muscle Shoals, Ala., is now master mechanic for D. P. Robinson & Co., Inc., and is located at the Colfax power station which that company is constructing for the Duquesne Light Co., of Pittsburgh.

George S. Blankenhorn, who was formerly experimental engineer of the Allis-Chalmers Manufacturing Co., and engineer of steam and propulsion machinery of the American International Shipbuilding Corp., has been connected with the Coen Co., San Francisco, since last August as chief engineer.

W. W. Fisher is no longer chief engineer of Old Hickory Power Plant, having been appointed a member of the new Sales Control Committee which the Government is to maintain at the plant for a number of years. This change was a result of the recent sale of Old Hickory to the Nashville Industrial Corporation.

Albert M. Wolf and Lawrence M. Harper have associated under the firm name of Wolf & Harper, Engineers, to conduct a general engineering business, with offices at Room 1508, 7 West Madison St., Chicago. The new firm will specialize in the complete design of commercial and industrial buildings and structures, power plants, the valuation and appraisal of properties, and the preparation of engineering reports.

Society Affairs

Hartford Branch, A. S. M. E., will meet at the City Club on Feb. 7 to hear George Otis Smith speak on "Industry's Supply of Energy."

Cincinnati Section, A. S. M. E., will hold a dinner, inspection trip and discussion on Feb. 1 at the Western Power Station of the Union Gas and Electric Co.

Robert Fulton Association, Illinois 28, N. A. S. E., is to hold an initiation at its meeting on Feb. 5 at Masonic Temple, Chicago. J. M. Spitzglass will speak on "Boiler-Room Efficiency."

Boston Section, American Institute of Electrical Engineers, will hold a meeting Feb. 8, at which W. M. White, of the Allis-Chalmers Mfg. Co., will speak on "Recent Waterwheel Developments and Settings."

The American Institute of Mining and Metallurgical Engineers will hold its annual meeting, Feb. 14-17, in the Engineering Societies' Building, New York City. Coal, gas and petroleum will come in for considerable discussion. Extensive preparations have been made for the entertainment of ladies. The annual banquet will be held at the Waldorf-Astoria Hotel Feb. 16.

The American Institute of Electrical Engineers is to hold its Ninth Midwinter Convention at the Engineering Societies Building, New York City from Feb. 16-18. Wednesday afternoon, Feb. 16, will be devoted to preparatory matters and inspection of local electrical plants, and in the evening papers will be presented on "Present-Day Practice Limitations of Oil Circuit-Breakers," by H. R. Woodrow, of Stone & Webster, and on "High-Current Tests on High-tension Switch Gear," by Philip Torchio, of the New York Edison Co. Thursday will be given over to technical sessions, and in the evening there will be a dinner-dance at the Hotel Astor at 7 o'clock. On Friday there will be more technical sessions, in one of which R. E. Doherty and E. T. Williamson, of the General Electric Co., will speak on "Short-Circuit Current of Induction Motors and Generators." In the evening the Edison Medal will be presented to Dr. M. I. Pupin, who will then give a lecture on "Wave Transmission."

FUEL PRICES

BITUMINOUS

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

	Nov., 1919*	Aug. 5, 1920	Jan. 6, 1921	Jan. 27 1921
Pittsburgh steam	$2.30	$10.00	$2.60	$2.50
Pittsburgh screened gas	2.30	12.00	3.15	3.25
Hocking	2.50	9.00	2.50	2.25
Franklin, Ill.	2.35	6.50	3.00	2.75
Indiana 4th vein	2.35	7.50	2.75	2.50
Eastern Ohio, No. 8	2.35	10.50	2.75	2.60
Fairmont	2.50	13.50	2.40	2.15
Kanawha	2.60	14.00	2.80	2.50
S. E. Kentucky	3.00	10.50	2.90	2.70
Western Kentucky	2.35	5.25	2.60	2.35
Clearfield	2.95	12.00	3.25	2.85
Cambria and Somerset	2.95	13.50	4.35	3.60
New River	2.70	14.00	4.50	3.60
Pocahontas	2.35			

* Government prices.

DIESEL FUEL OIL

Philadelphia—In tank cars: 26@28 deg. Baumé 10c. per gal.; 30@34 deg., 12c.; 16@20 deg. boiler oil, 8c.

Cleveland—In tank cars: 24@30 deg. Baumé (group 3), $1.40 per bbl.; 32@36 deg. (group 3), gas. oil, 5c. per gal. No market for boiler oil at this season.

Cincinnati—In tank cars: 26@28 deg. Baumé. 10c. per gal.; 30@34 deg., 10c. No market for boiler oil.

Chicago—For 24@26 deg. Baumé, $1.40@$1.50 per bbl.; 32@34 deg., 5@5½c. per gal. No market for boiler oil.

New Construction

PROPOSED WORK

Mass., Boston—Durant, Inc., c/o Dr. B. A. Denig, Pres., 541 Boylston St., is having plans prepared for a 10 story club building, hotel and gymnasium. Coolidge & Carlson, 89 State St., Archts.

Mass., Three Rivers—The Palmer Mills is having plans prepared for a 1 story, 30 x 70 ft. transformer building at its plant. Lockwood, Greene & Co., 60 Federal St., Boston, Archts. and Engrs.

R. I., Newport—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., plans to install refrigerator equipment at the Naval Hospital here.

Conn., Bridgeport—H. O Fletcher, 170 Norland Ave., is in the market for a ½-hp. single-phase motor.

N. Y., Endicott—The Water Dept. is arranging for the installation of electrically operated pumping equipment at the municipal waterworks.

N. Y., New York—The Pub. Service Comn., 49 Lafayette St., will receive bids until February 15 for furnishing and delivering pumping equipment. About $8,000.

N. Y., New York—Estate of W. W. Astor, 23 West 26th St., having sketches prepared for altering a 10 story, 200 x 288 ft. hotel on Bway. between 44th and 45th Sts. About $500,000. Peabody, Wilson & Brown, 140 East 39th St., Archts. and Engrs.

N. Y., Rochester—Berger Bros., 39 North Water St., are in the market for electric motors. W. Berger, Pur. Agt.

N. Y., Waddington—The New York & Ontario Power Co., Ogdenburg, has applied to the Federal Power Commission for permission to build a dam, 37 ft. high and 1,300 ft. long, across the south channel of the St. Lawrence River between Ogden Island and the American shore, here. Approximately 25,000 hp. will be developed.

N. J., Elizabeth—Elizabeth Theater will soon award the contract for a theater including a steam heating system. About $300,000. J. Wentworth, Paterson, Archt. and Engr.

N. J., Lakehurst—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., plans to install a steam distributing and condensate return system between the power house, hangar and auxiliary shop at the Naval Air Station here.

N. J., Trenton—W. Hankin & Son, Archts., 942 Carteret St., will soon award the contract for an apartment and office building. About $800,000. Owner's name withheld.

Pa., Williamsport—The Bd. Educ., c/o H. A. Sterner, Secy., 229 West 3rd Street, will receive bids until February 10 for furnishing and installing a heating and ventilating system in Clay School. About $10,000.

Md., Baltimore—The Amer. Oil Co., 915 Amer. Bldg., is having plans prepared for a 40 x 100 ft. warehouse on Ranstead's Wharf. About $150,000. A boiler house will be built later. R. G. Callis, Jr., Amer. Bldg. Archt.

D. C., Brookland (Washington P. O.)—The Augustinian Order, c/o Rev. Father F. J. McShane, will open bids soon for the construction of an addition to the college building. About $500,000. J. J. Kennedy, Ford Bldg., Wilmington, Del., Archt.

N. C., Charlotte—The Southern Power Co., Church St., plans to erect a hydro-electric plant on the Catawba River to develop 35,000 hp. About $8,000,000. W. S. Lee, Vice-Pres. and Engr.

Ala., Bellwood—The city of Dothan plans an election to vote on $750,000 bonds for the construction of a power plant on the Choctawhatchie River here.

Ala., Gadsden—The Alabama Power Co., Birmingham, has been granted permission to construct a transmission line from here to the Georgia state line to connect with the line of the Georgia Ry. & Power Co. T. W. Martin, Pres. Noted June 15.

La., Shreveport—The city is having plans prepared for a pumping station. J. N Chester Co., Union Bank Bldg., Pittsburgh, Pa., Engrs.

Tenn., Memphis—C. O. Pfeil and G. Awsumb, Archts., 1403 Union & Planters Bldg., will receive bids March 1 for a municipal market and auditorium including steam heating, ventilating and metal blower systems. Plans also include an electric power plant. About $2,000,000.

O., Akron—The University of Akron plans to build an engineering building. Equipment includes metallurgical laboratory, steam turbine, Semi-Diesel oil engine, etc. About $100,000.

O., Cleveland—D. Roseman of the Federal Coffee Co., 733 Woodland Ave., plans to build a 4 story commercial building. About $300,000. Architect not selected.

O., Cleveland—The Federal Reserve Bank, Williamson Bldg., is having plans prepared for a 10 story bank building including a steam heating system at East 6th St. and Superior Ave. About $2,500,000. Walker & Weeks, 1900 Euclid Ave., Archts.

O., Cleveland—The Bd. Educ., F. G. Hogan, Dir., will receive bids until February 10 for a 2 story school including a steam heating system on Euclid Ave. near Woodcliff Ave. About $250,000. W. R. McCormack, East 6th Street and Rockwell Ave., Archt.

O., Cleveland—Dr. J. P. Henahan, Rose Bldg., has purchased a site at 3312 Prospect Ave. and plans to build an office building. About $250,000. Architect's name withheld.

O., Columbus—The Ohio State Savings Assn., 44 East Broad St., is having sketches prepared for a 5 story, 42 x 125 ft. office building at Gay and 3rd Sts. About $300,000.

O., Columbus—The Y. M. C. A., South 3rd St., plans to build an 8 story, 187 x 187 ft. Y. M. C. A. building on Long and Front Sts. About $800,000. W. F. Shattuck, 19 South La Salle St., Chicago, Ill., Archt.

O., Dayton—B. F. Keith Theater Co., 5th and Ludlow Sts., is having plans prepared for a 125 x 200 ft. theater on Main near First Sts. About $800,000. G. L. & C. W. Ropp, 190 North State St., Chicago, Ill., Archts.

O., Toledo—The Holt Farm Light Co. incorporated with capital stock of $100,000, has taken over the plant of the Automatic Light Co., Ludington, Mich., and will operate same until a site is secured here for a 4 story factory to cost about $300,000.

O., Youngstown—The Bd. Educ. will receive bids until February 7 for a 2 story, 222 x 312 ft. school on Ohio Ave. About $400,000. C. F. Owlsey, Mahoning Bank Bldg., Archt.

O., Youngstown—Stanley & Scheibel, Archts., Wick Bank Bldg., will open bids about March 1 for a 2 story, 80 x 100 ft. temple on Elm St. for Anshe Emeth Congregation. A steam heating system will be installed in same. About $300,000.

Ind., Crown Point—J. N. Coleman, Archt., 6257 St. Lawrence Ave., Chicago, Ill., will receive bids about February 15 for several hospital buildings here including a steam heating system and a 50 x 50 ft. power plant. About $350,000. Noted Dec. 14.

Ind., Frankfort—The City Council plans to build a power plant. About $175,000. M. A. Petty, City Clk.

Ind., Muncie—The Delaware Co. State Bank, c/o Arney Co., Archts., 10 South La Salle St., Chicago, Ill., had plans prepared and will open bids about March 1 for a 7 story, 23 x 130 ft. bank and office building here, including a steam heating system. About $500,000.

Mich., Cadillac—St. Mary's Hospital is having plans prepared for a 3 story hospital. About $250,000. E. Brielmaier & Sons, 432 Bway., Milwaukee, Wis., Archts.

Mich., Detroit—The Public Lighting Commission, c/o A. L. Jones, acting president, 138 East Atwater St., plans to build a 25,000-kw. lighting plant to supply municipal street cars, fire department high pressure pumping station with power, also energy for lighting streets and public buildings. About $500,000. Engineer not selected.

Mich., Detroit—The Y. M. C. A., c/o Dr. A. G. Studer, Adams Ave., plans to build a 6 story office and hotel building including a steam heating system at Adams Ave. and Witherell St. About $400,000. Architect not selected.

Mich., Flint—The Durant Motors Corp., c/o Chamber of Commerce, plans to build a 3 story automobile plant. About $500,000. Engineer not selected.

Ill., Chicago—The Overton Hygienic Mfg. Co., 5200 South Wabash St., will soon award the contract for a 5 story, 65 x 130 ft. loft and store building including a steam heating system on State St. and 36th Place. About $350,000.

Ill., Du Quoin—The Browning Hospital will receive bids until February 21 for a 3 story hospital including a steam heating system. About $500,000. N. S. Spencers & Sons, 37 West Van Buren St., Chicago, Archts.

Ill., Wilmette—The Bahai Temple Unity will soon receive bids for the superstructure of a 9 sided temple, 120 ft. in diameter. About $2,000,000. L. Bourgois, Archt., c/o H. J. Burt, Engr., 104 South Michigan Ave., Chicago.

Wis., Milwaukee—A. S. Hecht, Archt., 64 Randolph, Chicago, Ill., representing owner, is preparing plans for an 11 story, 200 x 210 ft. hotel at Sycamore and West Water Sts., here. About $500,000.

Wis., Milwaukee—The city has $500,000 available to build new Riverside pumping station. G. Staal, City Engr.

Wis., New London—The Exner Garment Mfg. Co., Berlin, plans to build a 4 or 5 story, 60 x 125 ft. garment factory here. Power machinery will be required. About $50,000. Architect not selected.

Wis., Oconomowoc—The city plans to install a new switchboard in the municipal light plant and in an outside sub-station. T. S. Johnson, City Clk.

Minn., Minneapolis—Hennepin Co. Sanatorium Comn., E. C. Gale, plans to build a sanatorium to cost $1,500,000 including a power plant at $210,000, on Glen Lake. Architect not selected.

Minn., Minneapolis—The city and state, c/o C. A. Bloomquist, City Treas. and member of the Armory Comn., plans to build a 3 or 4 story armory on the parade grounds. About $500,000. Architect not named.

Minn., Osakis—The city rejected all bids for the construction of a pumping station and installation of equipment to cost about $10,000. C. G. Millard City Clk.; C. L. Pillsbury Co., 1206 2nd Ave., Minneapolis, Engrs. Noted Nov. 20.

Kan., Parsons—The city is having plans prepared for rehabilitation of waterworks plant. Plans include rebuilding power plants, installation of filter equipment and machinery for 6,000,000 gal. capacity, etc. About $350,000. Burns & McDonnell Engrg. Co., Interstate Bldg., Kansas City, Mo., Consulting Engrs.

N. D., Grafton—The State Home for the Feeble-Minded plans to build several buildings including power house, workshop and milkhouse. About $583,500.

Wyo., Laramie—The Midwest Refining Co. plans to install one 500-kva, 2,300-volt, 60-cycle, steam-driven generator; three 125-hp. motors for water pumping and one 100-hp. motor for boiler feed. J. F. Cullen, Supt.

Mont., Lewiston—The Bd. Educ., c/o A. A. Franzke, Supt. of Schools, plans to build 2 story school including a steam heating system. Architect not announced.

Mo., Kansas City—Dickey Memorial Church, c/o Lowe & Bollenbacker, Archts., 108 South La Salle St., Chicago, Ill., is having plans prepared and will receive bids about February 15 for a church here, including a steam heating system. About $400,000.

Mo., St. Louis—A. E. Morelock, Carleton Bldg., representing owner, plans to build a 109 x 160 ft. theater at 19th and Chestnut Sts. About $500,000.

Tex., Crockett—Houston Co. Levee Imprt. Dist. 1, c/o H. J. Arlege, Chn., had surveys prepared for building 4½ mi. levee to reclaim 75,000 acres of fertile land in Trinity River bottom, including erection of sluice gates, pumping plants, etc. About $150,000. H. J. Cox of Cox Engrg. Co., 1008 Dallas Co. State Bank Bldg., Dallas, Engr.

Tex., Hillsboro—The Shear Co. is having plans prepared for a cold storage plant including equipment. About $25,000.

Col., Denver—Fidelity Impvt. Co., 705 Central Savings Bank Bldg., is having plans prepared and will receive bids in March for an 8 story apartment house at 14th Ave. and Washington St. About $600,000. H. J. Manning, Majestic Bldg., Archt.

Col., Grand Valley—The Harrison Petroleum Co. is having plans prepared for a 1,000-ton shale oil refinery. Three 150-hp. boilers, one 250-hp. Peerless compressor engine, ten 100-ton retorts, steam stills, agitators, crushers and conveying machinery will be installed in same. About $500,000. H. C. Wolf, Oklahoma City, Okla., Engr.

Col., Greeley—The Colorado State Normal School will soon award the contract for seven 2 story dormitories including a steam heating system. About $280,000. W. B. Ittner, Bd. Educ. Bldg., St. Louis, Mo., Archt.

Cal., Modesto—The city is having plans prepared and will receive bids about April 1 for the construction of the Don Pedro Dam, 283 ft. high above stream bed, 270 ft. thick at base, 16 ft. at top and 1,000 ft. long. Estimated cost including power development project, about $3,075,000. A. J. Wiley, Engr.

Cal., San Diego—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., plans to install a heating system here.

Que., Montreal—The Shipman Electric Engr. Co., 26 St. George St., is in the market for one 7½-hp., 110-volts, single-phase Wagner or Century motor; one 350-kva., 3-phase, 60-cycle, 600-volt synchronous motor; one 150-kw., 220 to 110 volt, 3-wire, d.c. generator.

Ont., Branford—The city voted $170,000 bonds for waterworks extensions including pumps, mains, etc. P. Adams, City Engr.

Ont., London—The Uutilities Comn., E. V. Buchanan, Gen. Mgr., will receive bids about March 1 for a 2 story, 45 x 85 ft. substation on Cabell St. About $50,000 Noted Nov. 30.

Ont., London—The City Council is having plans prepared and will receive bids in February for a 6 story, 80 x 100 ft. city hall including a steam heating system on Dundas St. About $400,000. A. M. Piper City Archt.

Ont., Parry Sound—The Town Council is in the market for 1 return tubular steel boiler, 12 ft. long, 60 in. in diameter, 125 lbs. steam pressure, full front and anchor bolts, shaking grates, safety valves, water column blow-off valve, steam gauge. About $5,000. J. D. Broughton, Clk.

Ont., Toronto—The Dept. of Pub. Wks., Parliament Bldgs., plans to build an office and administration building at Queens Park, here. About $1,500,000. F. R. Heakes, above address, Provincial Archt.

Ont., St. Thomas—The city voted $233,000 for the construction of a dam across Keille Creek, sinking new wells, changing electric pumps, etc. W. C. Miller, City Engr.; R. S. and W. S. Lea, New Birks Bldg., Montreal, Consulting Engrs.

Ont., Winsdor—The Municipal School Boards of Winsdor and Walkerville, Winsdor, will soon award the contract for a 3 story technical school here, including a vacuum steam heating and ventilating system. About $500,000. A. M. McPhail, 14 London St., Archt.

Mexico, Tampico—The Standard Oil Co of New Jersey, 26 Bway., New York City, plans to build a large pumping station here, to include 12 pumping units, a battery of 28 boilers, and auxiliary pumping equipment. Two central power plants for oil field service will be built.

CONTRACTS AWARDED

N. Y., Astoria, L. I. (Long Island City P. O.)—S. Bloom, 1451 Bway., New York City, will build apartments, theater and hall including a steam heating system at Steinway Ave., Bway. and 11th St., here. Work will be done by day labor.

N. Y., New York—The Melrose Ave. Corp., c/o G. F. Pelham, Archt. and Engr., 200 West 72nd St., will build a 6 story, 70 x 100 ft. apartment including a steam heating system at Riverside Drive and 148th St. About $250,000. Work will be done by day labor.

Va., Richmond—Liggett & Meyers Tobacco Co. has awarded the contract for a 5 story factory to H. K. Ferguson Co., 6523 Euclid Ave., Cleveland, Ohio. About $400,000.

W. Va., South Charleston—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., has awarded the contract for the installation of sub-station switchboards at the Naval Ordnance Plant here, to the Westinghouse Electric & Mfg. Co., 308 Hibbs Bldg., Washington, D. C. Noted Jan. 11.

Fla., Orlando—United Markets, Inc., N. Rosenblatt, Gen. Mgr., Tampa, will build a 6-ton ice and refrigerating plant here. Full equipment for cold storage and retail meat market will be required. About $15,000. A. B. Hale, Tampa, Engr. Work will be done by day labor.

Minn., St. Paul—The city awarded the contract for a 54 in. x 60 ft. steel return tubular boiler to Kenney Boiler & Mfg. Co., 6th and Locust Sts., at $1,815. Noted Jan. 18.

Cal., Los Angeles—F. W. Woolworth Co., 719 Bway., has awarded the contract for a 3 story, 60 x 170 ft. store building to McDonald & Kahn, 905 Washington Bldg., at $160,000. A steam heating system and boiler plant will be installed in same.

Ont., Nassau (Peterborough P. O.)—The Dom. Govt., Ottawa, and the Canadian General Electric Co., 212 King St., West, Toronto, have awarded the contract for a dam on the Otonaba River near here, to Sheehey Bros., at $250,000.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		75c. per ft.
Common, 2½-in.		40%

	Air		
	First Grade	Second Grade	Third Grade
¼-in. per ft.	$0.50	$0.35	$0.25

Steam—Discounts from List

First grade..... 30% Second grade..... 45% Third grade.. 50-10%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 60% Best grade..... 35%
Standard..... 50%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz. rolls):

Light Grade	Medium Grade	Heavy Grade
30-10%	30%	25%

RAWHIDE LACING { For cut, best grade, 35%, 2nd grade, 40%. / For laces in sides, best, 63c per sq. ft.; 2nd, 62c. / Semi-tanned: cut, 25%; sides, 65c per sq. ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$1.00
Asbestos for high-pressure steam	2.00
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.70
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.50
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.50
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are part of standard lists, with discounts.

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... List +5%

For low-pressure heating and return lines { 4-ply..... 50% off / 3-ply..... 52% off / 2-ply..... 54% off

PORTLAND CEMENT—New York, $3 20 without bags, in cargo lots delivered on job.

STRUCTURAL STEEL—New York warehouse price, 3 to 15-in. beams and channels and 3 to 6-in. angles and tees; all $3.58 per 100 lb.; plates, $3.78.

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
White	7.50@13.00	13.00	15.00	14.25
Colored mixed	7.00@11.00	9.00 to 12.00	11.00	12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$55.00	$65.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York		Chicago	
	Current	One Year Ago	Current	One Year Ago
Raw in barrels (5 bbl. lots)	$0.83	$1.80	$0.94	$2.37
5-gal. cans	.90	2.00	1.19	2.57

With lower prices obtainable in New York.

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	13.00	14.50	13.00	14.50	13.00	13.00
25- and 50-lb. kegs	13.25	14.75	13.25	14.75	13.25	13.25
12½-lb. keg	13.50	15.00	13.50	15.00	13.50	13.50
1-lb. cans	16.00	17.50	15.00	16.50	16.00	15.00
5-lb. cans	18.00	19.50	16.00	17.50	18.00	16.00

500 lb. lots less 10% discount; 2000 lb. lots less 10-2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	40%	50%	30%
Tinned	40%	50%	30%

Boiler rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York..... $6.00 Chicago..... $5.83 Pittsburgh..... $4.60

Structural rivets, same sizes:

New York..... $5.13 Chicago..... $5.73 Pittsburgh..... $4.50

REFRACTORIES—Prices in carlots:

Bauxite brick, 56% alumina, f.o.b. Pittsburgh	per 1000	$160
Chrome brick, eastern Shipping points	net ton	80
Chrome cement, 40@45% Cr_2O_3	net ton	50@ 55
Chrome cement, 40@45% Cr_2O_3 in sacks	net ton	55@ 60
Clay brick, 1st quality, fire clay, 9-in. shapes, Pennsylvania, Ohio and Kentucky	per 1000	55@ 60
Clay brick, 2d quality, fire clay, 9-in. shapes Pennsylvania, Ohio and Kentucky	per 1000	45@ 50
Magnesite brick: 9-in. straight	net ton	100
Magnesite brick: 9-in. arches, wedges and keys	net ton	105
Magnesite brick: Soaps and splits	net ton	120
Silica brick: Chicago district	per 1000	65@ 70
Silica brick: Birmingham, Ala.	per 1000	56@ 61
Silica brick: Mt. Union, Pa.	per 1000	55@ 60

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	70.00	90.00	44.00	70.00	40.00	60.00
Commercial	30.00	50.50	16.50	16.50	9.00	13.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting or screw stock, per 100 lb. base	$5.50	$5.80	$4.84
Flats, square and hexagons, per 100 lb. base	6.00	6.30	5.34

SHEETS—Quotations are in cents per pound in various cities from warehouse; also the base quotations from mill:

	Large Mill Lots	New York			
Blue Annealed	Pittsburgh	Current	One Year Ago	Cleveland	Chicago
No. 10	3.55	4.68	5.50–6.00	4.50	4.68
No. 12	3.60	4.73	5.56	4.60	4.83
No. 14	3.65	4.78	5.92	4.65	5.03
No. 16	3.75	4.88	6.02	4.75	5.13
Black					
Nos. 18 and 20	4.20	4.58	6.80–7.80	5.30	5.80
Nos. 22 and 24	4.25	4.63	6.85–7.85	5.45	5.85
No. 26	4.30	4.68	6.90–7.90	5.50	5.90
No. 28	4.35	4.78	7.00–8.00	5.60	6.00
Galvanized					
No. 10	4.70	6.13	6.50	5.95	5.30
No. 12	4.80	6.23	6.60	6.05	5.40
No. 14	4.80	6.23	6.60	6.05	5.40
Nos. 18 and 20	5.10	6.53	6.90	6.35	5.70
Nos. 22 and 24	5.25	6.68	7.05	6.50	5.85
No. 26	5.40	6.83	7.20	6.65	5.90
No. 28	5.70	7.13	7.50–9.00	7.95	6.00

An additional charge of 10c. per 100 lb., is made for trucking in Jersey City and 15c. for New York and Brooklyn

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the Pittsburgh basing card:

BUTT WELD

Steel			Iron		
Inches	Black	Galv.	Inches	Black	Galv.
⅜ to 3	54 to 57½	41½ to 44	⅛	15½ to 25½	+1½ to 11
			¼	19½ to 29½	1½ to 11½
			⅜ to 1¼	24½ to 34½	8 to 18½

LAP WELD

2	47 to 50½	34½ to 38	2	20½ to 28½	6½ to 14½
2½ to 6	50 to 53½	37½ to 41	2½ to 6	22½ to 30½	9½ to 17½
7 to 12	47 to 50½	33½ to 37	7 to 12	19½ to 27½	6½ to 14½
13 and 14	37½ to 41				
15	35 to 38½				

BUTT WELD, EXTRA STRONG, PLAIN ENDS

¼ to 1½	52 to 55½	39½ to 43	¼ to 1½	24½ to 34½ 9½ to 19½
2 to 3	53 to 56½	40½ to 44		

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	45 to 48½	33½ to 37	2	21½ to 29½	8½ to 16½
2½ to 4	48 to 51½	36½ to 40	2½ to 4	23½ to 31½	11½ to 19½
4½ to 6	47 to 50½	35½ to 39	4½ to 6	22½ to 30½	10½ to 18
7 to 8	43 to 46½	29½ to 33	7 to 8	14½ to 22½	2½ to 10½
9 to 12	38 to 41½	24½ to 28	9 to 12	9½ to 17½	5½ to+2½

BOILER TUBES—The following are the prices for carload lots, f.o.b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	20 to 40%	1¼ to 1½ in.	23
2¾ to 3¼ in.	11 to 30%	2½ in.	+10 to +12
2¼ to 2½ in.	3 to 30%	2¾ in.	+1 to +10
1¼ to 1¾ in.	+7 to 19%	2¾ and 3¼ in.	—1½ to +3
		3½, 4 and 4½ in.	—8

Standard Commercial Seamless — Cold Drawn or Hot Rolled

Per Net Ton		Per Net Ton	
1 in.	$327	1¼ in.	$207
1¼ in.	267	2 to 2½ in.	177
2¼ in.	257	2¾ to 3½ in.	167
1¼ in.	207	4 in.	187
		4½ to 5 in.	207

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 65.00(net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	10%		List
Coils to 1,000 ft.	15%		10%
1,000 ft. and over	20%		—15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.43
12 to 50	.41
50 to 125 (bbl.)	.38
125 (bbl.) or over	.35

CONDUIT, Price per 1000 ft.; ELBOWS AND COUPLINGS, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

	Conduit		Elbows		Couplings	
Size, In.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.
¼	74.30	79.40	17.75	18.90	6.55	6.95
⅜	98.20	105.10	23.35	24.85	9.35	9.95
½	145.20	155.40	34.55	36.80	12.15	12.90
¾	196.40	210.20	44.25	46.95	16.75	17.75
1	234.85	251.35	59.00	62.65	20.65	21.90
1¼	316.00	338.20	108.25	114.85	27.55	29.20
1½	499.60	534.70	177.10	187.90	39.35	41.75
2	653.30	699.20	472.30	501.10	59.05	62.65
2½	813.30	886.50	1,043.05	1,106.65	78.70	83.50
3	995.35	1 050.75	1 205.40	1,278.90	98.40	104.40
4						

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
⅜	250	$0.05½
½	250	.06
¾	250	.09
¾	200	.12
¾	200	.15
¾	150	.18
1	100	.25
1¼	100	.33
1½	Odd lengths	40
2	Odd lengths	55

1000 ft. and over....55%
Coils....45%
Less coils, 35%

CUT-OUTS—Following are net prices each in standard-package quantities

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.43
D. P. M. L.	.21	T. P. to D. P. S. B.	.26
T. P. M. L.	.33	T. P. S. B.	.38
D. P. S. B.	.23	T. P. D. B.	.64

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.50	$1.30	$1.68
T. P. M. L.	.70	1.70	2.40
D. P. S. B.	.63	1.60	.....
T. P. S. B.	1.15	2.40	.....
D. P. D. B.	1.10	3.00	.....
T. P. D. B.	1.90	5.40	.....
T. P. to D. P. D. B.	1.30	3.80	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$17.72
No. 16 cotton twisted	21.89
No. 18 cotton parallel	22.00
No. 16 cotton parallel	25.40
No. 18 cotton reinforced heavy	31.62
No. 16 cotton reinforced heavy	35.45
No. 18 cotton reinforced light	29.30
No. 16 cotton reinforced light	32.00
No. 18 cotton Canvasite cord	22.97
No. 16 cotton Canvasite cord	27.06

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
110-amp. to 200-amp.	25	2.00
225-amp. to 400-amp.	25	3.60
425-amp. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package....15%
1-5th to standard package....28%
Standard package....45%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$5.25C
0-30 ampere, less than standard package	6.00C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs — Mazda B—				Pear-Shaped Bulbs — Mazda C—			
Watts	Plain	Frosted	No. in Package	Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.25	24
25	.40	.45	100	150	1.55	1.70	24
40	.40	.45	100	200	2.10	2.30	24
50	.40	.45	100	300	3.15	3.40	24
60	.45	.50	100				12
				500	4.60	4.90	12
				750	6.50	6.90	8
				1,000	7.50	7.95	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.28
Composition 2-piece attachment plug	.36
Swivel attachment plug	.20
Current taps	.45

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 8.25	$11.50	$15.08	$23.00
12	12.00	15.94	18.47	30.56
10	10.59	19.49	23.42	39.19
8	22.82	26.77	30.91	52.60
6	.....	.....	42.70	.....
4	.....	.....	59.00	.....
2	.....	.....	85.13	.....
1	.....	.....	107.95	.....
0	.....	.....	127.62	.....
00	.....	.....	150.14	.....
000	.....	.....	182.57	.....
0000	.....	.....	224.67	.....

Prices per 1000 ft. for Rubber-Covered Wire in Following Cities:

	Denver			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$13.50	$16.80	$30.80	$9.85	.....	$26.36
10	21.10	24.60	51.55	17.84	.....	43.05
8	27.60	32.35	67.60	23.89	.....	53.98
6	49.00	51.30	.....	.....	$47.46	.....
4	66.00	68.85	.....	.....	64.62	.....
2	93.50	95.0	.....	.....	90.87	.....
1	128.00	131.05	.....	.....	117.78	.....
0	175.00	175.00	.....	.....	143.13	.....
00	.....	.....	.....	.....	171.60	.....
000	.....	.....	.....	.....	207.09	.....
0000	.....	.....	.....	.....	248.82	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap			¾ In. Cap		
Key Each	Keyless Each	Pull Each	Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package....+50%
1-5th to standard package....+20%
Standard package....—15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	47c. lb.
No. 18 B. & S. regular 1-lb. coils	48c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 56c. lb., 100 lb. lots	52c. lb.
Rubber tape, ¾ in., less 100 lb. 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 47c. lb., 100 lb. lots	42c. lb.
Soldering paste, 2 oz. cans	$1.50 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	+25%
$10 to $25 list value	+10%
$25 to $50 list value	+ 5%
$50 to $200 list value	—10%
$200 list value or over	—15%